Evaluation and Management of Patellofemoral Disorders

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HARVARD MEDICAL SCHOOL

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SPORTS MEDICINE

Patellofemoral FOUNDATION

OUR MISSION STATEMENT

The Patellofemoral Foundation's mission is to improve care of individuals with anterior knee problems through targeted education and research.

1. Research

Fund carefully selected scientists to study the causes, prevention and treatment of patellofemoral disorders.

2. Education

Provide educational sports medicine and knee meetings in multiple locations to educate health care professionals about prevention and proper care of patients and athletes with patellofemoral pain and instability.

3. Innovation

Find new and improved methods for treating patients and athletes with patellofemoral pain, emphasizing minimal intervention and non-surgical methods.

4. Awareness

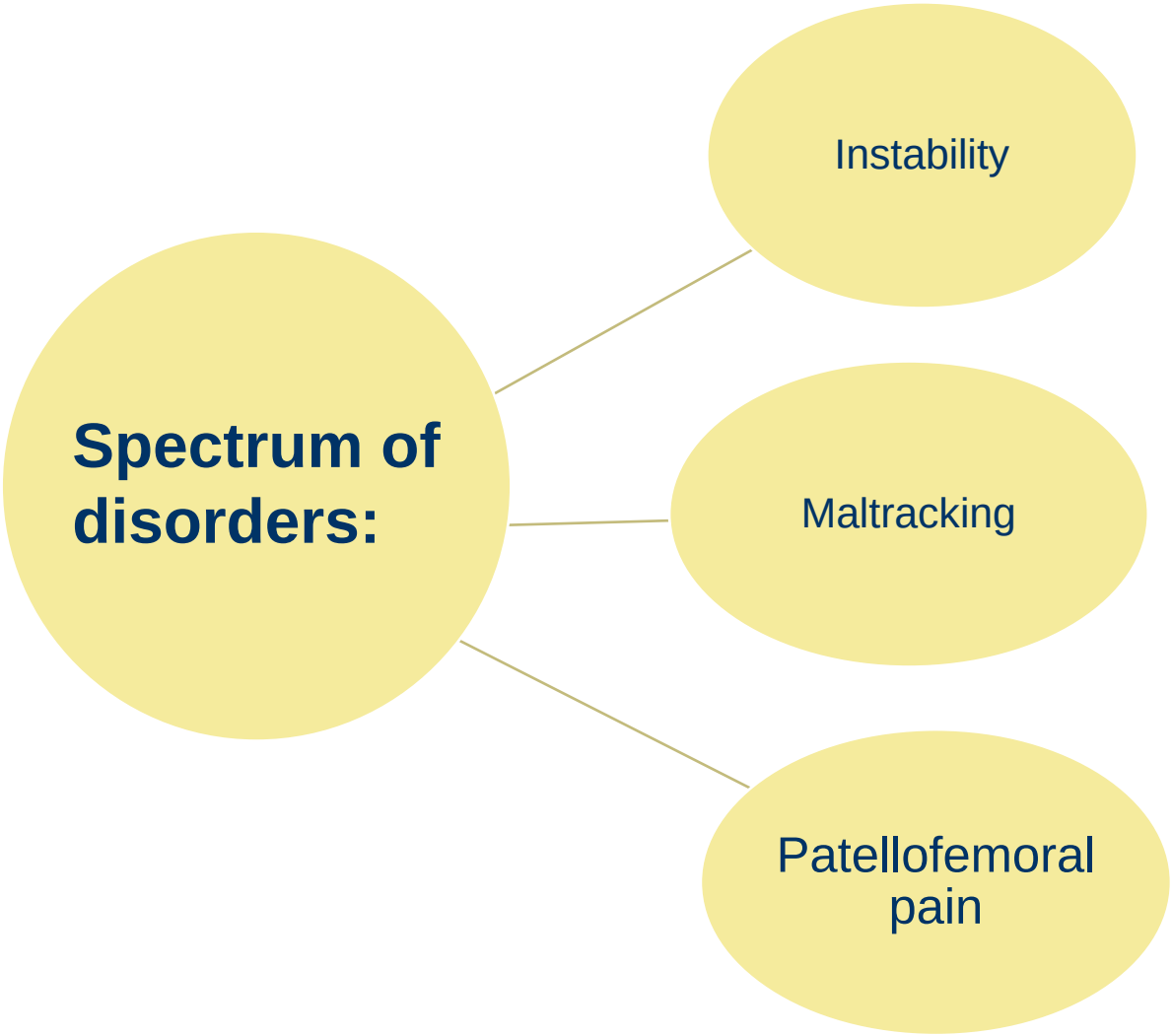
Enhance awareness of patellofemoral problems, the prevalence of patellofemoral pain, and the impact on athletes, workers and the economy.

www.patellofemoral.org

Disclosures

- Financial: None
- Board/Committee: AAOS, AOSSM, Editorial Board AJSM, CME Assoc Editor JBJS

Patellofemoral disorders



Patellar Instability

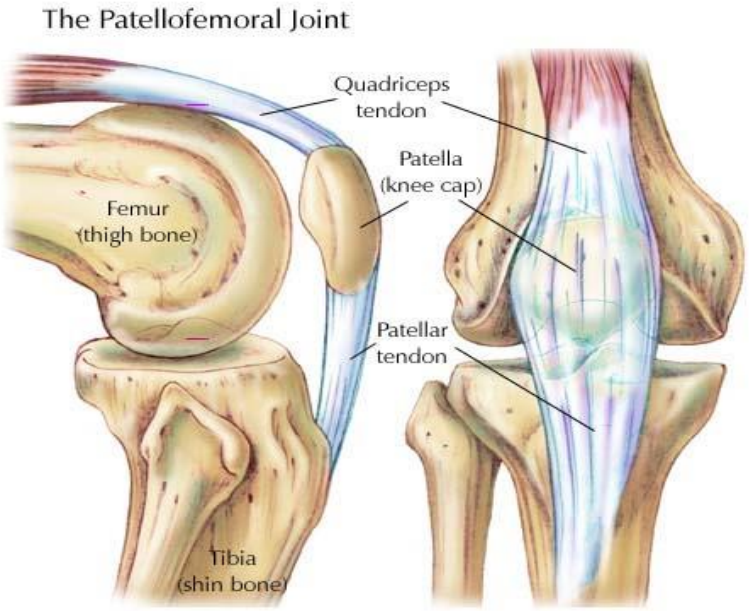
- Can be traumatic or atraumatic
- Patellar restraints:
  - ligamentous restraints
  - dynamic muscular forces
  - bony anatomy
- Disruption of any combination of these 3 components can lead to patellar instability

Epidemiology

- Most common onset during adolescence (10–17 years old)
- Highest risk in female adolescents
- 5.8-29/100,000
- Most common in football, basketball, soccer (Waterman 2012)
- A 9% incidence of a positive family history is noted
- Previous dislocations (49% of patients with a dislocation have a history of a previous dislocation)

Patellofemoral anatomy

- Patella
  - Sesamoid bone: embedded in tendon
  - Fulcrum for quadriceps muscle in extending the knee



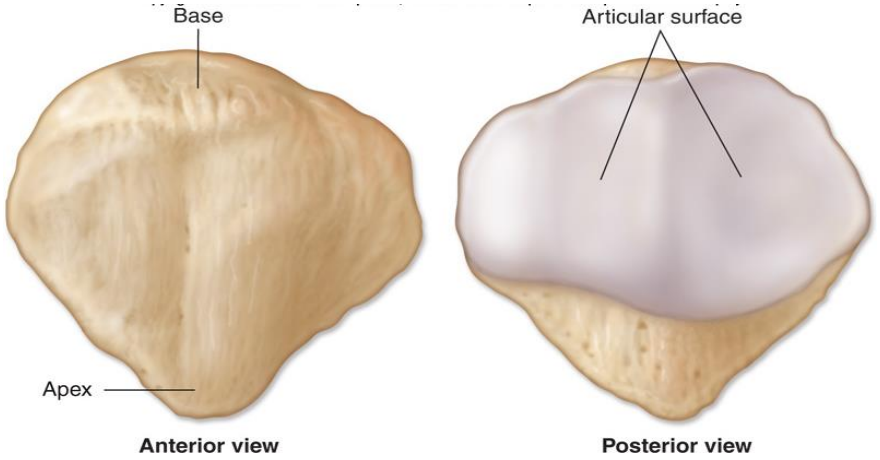
- Trochlea/Femur
  - The “groove”

www.hughston.com/hha/b.pfjoint.jpg

Patella

- Cartilage undersurface
- =>

  Patellofemoral *Joint*



http://academic.kellogg.edu/herbrandsonc/bio201_mckinley

Patellofemoral Instability

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- **Subluxation** :
  - transient lateral movement of the patella

  →feeling of instability or pain

  Vs
- **Maltracking**: abnormal lateral tracking of the patella

  (Fulkerson 2004)

  Vs
- **Laxity:** abnormal translation

Patellofemoral dislocation

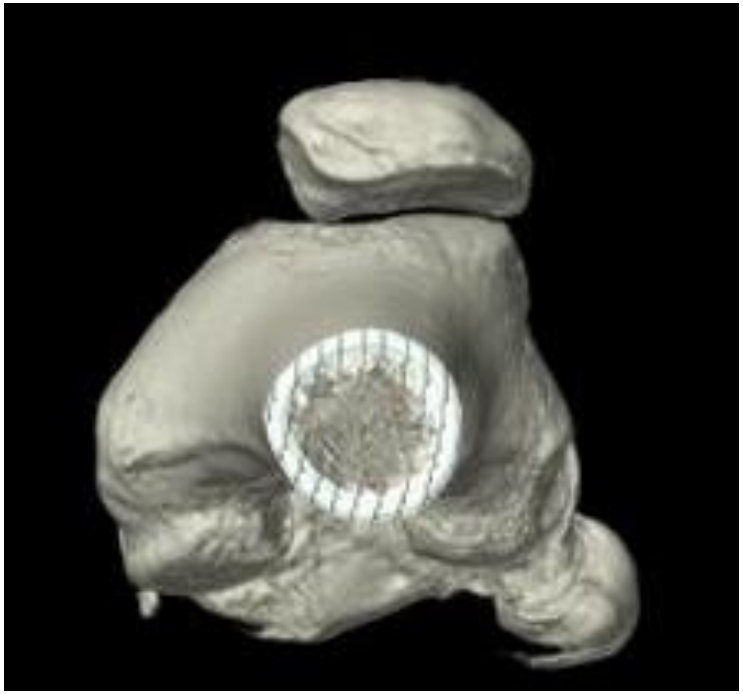
Hughston, JBJS 1968

- Mechanism (Hughston 1948, Agletti 2001):
  - external rotation of tibia
  - valgus force
  - slight flexion
- Hughston (JBJS 1968)
  - 74 knees with pf dislocation event
  - 73% had predisposing factors

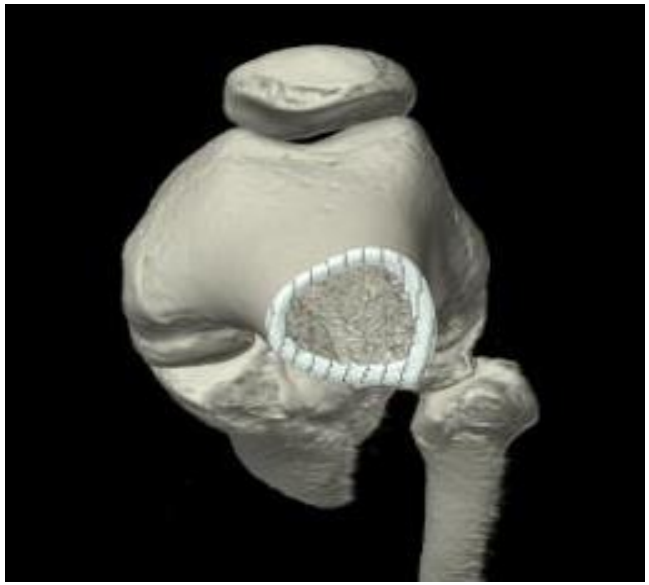
Predisposing factors

Typical “morphotype” of the patellar dislocator

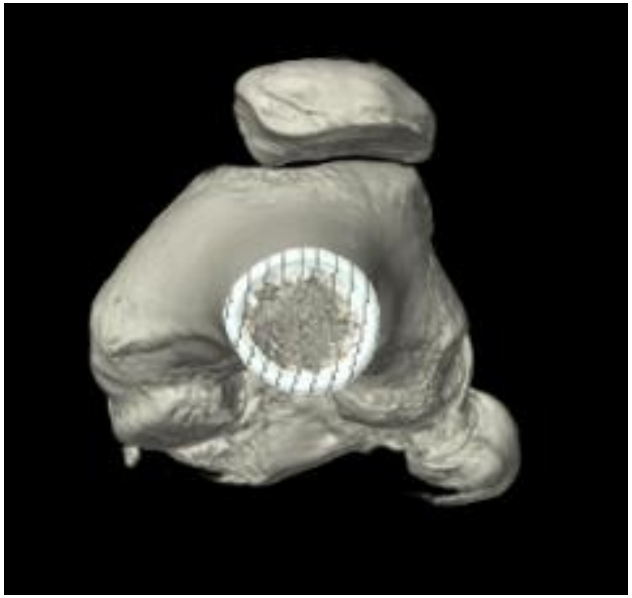
- Trochlear dysplasia
- Patella alta
- Rotational and angular bony malalignment: femoral anteversion, pes planus
- Ligamentous laxity



Trochlear Dysplasia



- Normal Trochlea
  - Bony constraint at flexion >30 degrees



- **Trochlear dysplasia**
  - **96% of 143 knees with patellar instability (Dejour 1994)**

Trochlear Dysplasia

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- “Flattened groove”
- Bilateral in 92.5%

  (Dejour 1994)
- Associated with patella alta (Hvid 1983, Liebensteiner 2018)

Normal vs abnormal morphology

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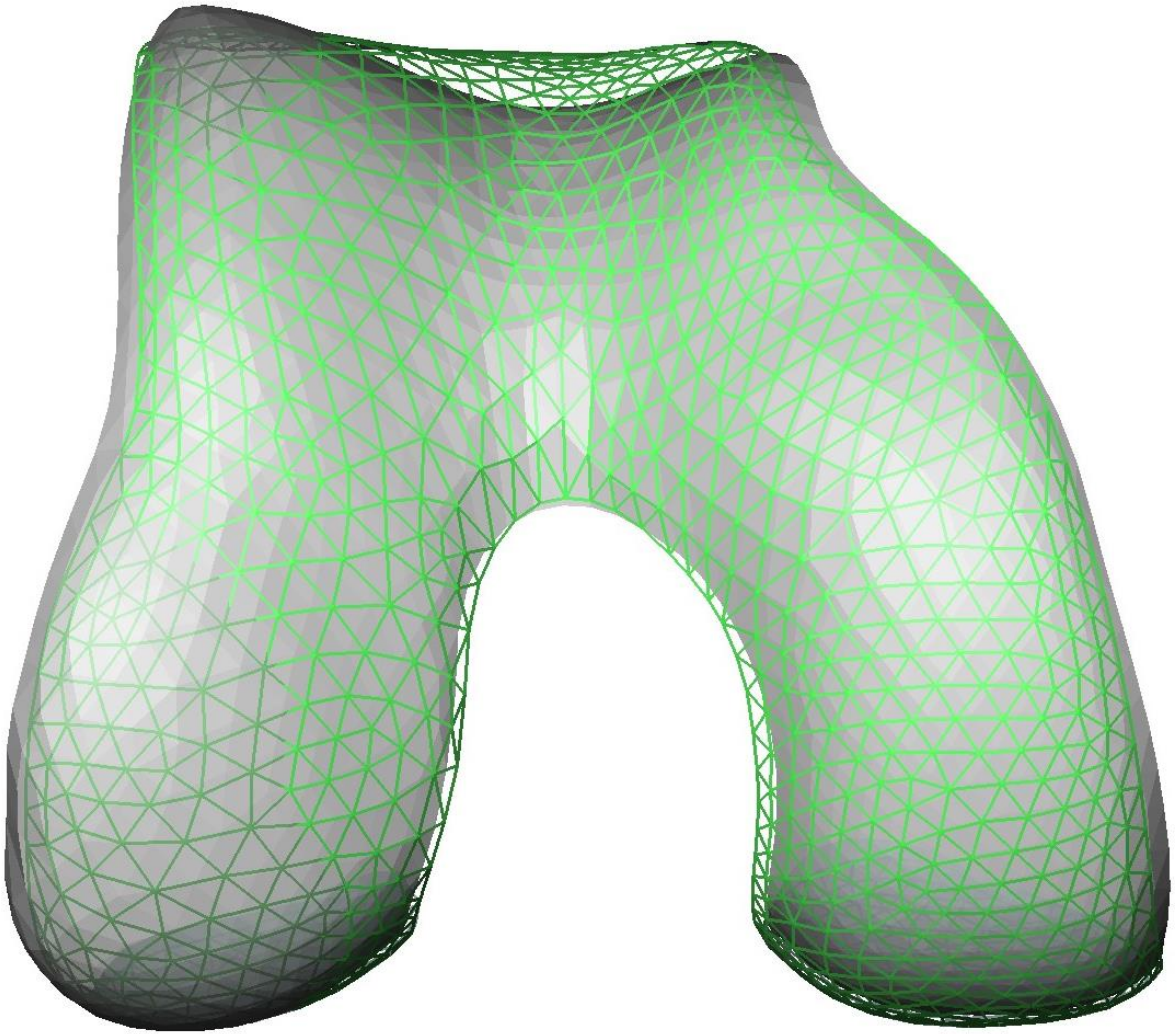


Patella Alta

- Associated with patellar dislocation (Hughston 1968, Insall 1971, Insall 1972, Geenen 1989, Brattsrom 1964)
- More likely to have dislocation without trauma (Hughston 1968, Geenen 1989)
- “High-riding patella does not engage the trochlea in time” (Geenen 1989)

Bony Malalignment

- Femoral anteversion
- Genu valgum
- External tibial torsion

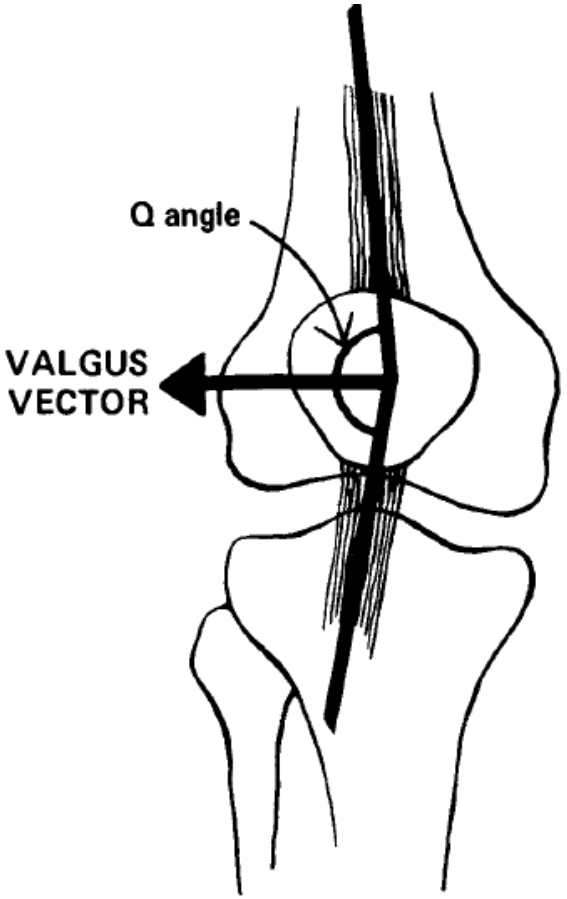
- Leads to lateralizing force on extensor mechanism

Tanaka et al, in OKU Sports Medicine 2015

Bony Malalignment

"The kinesiological basis…

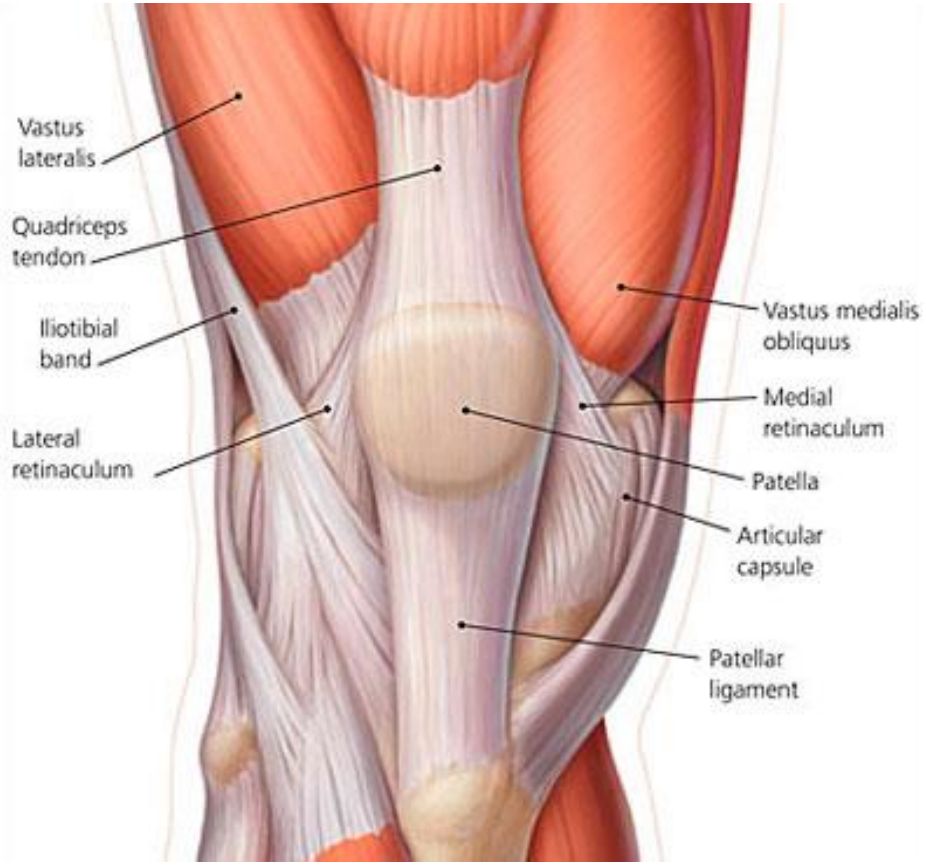
involves a ***contracting quadriceps mechanism seeking the shortest route between origin and insertion***." (Cox 1976)



Hungerford 1990

Dynamic restraints

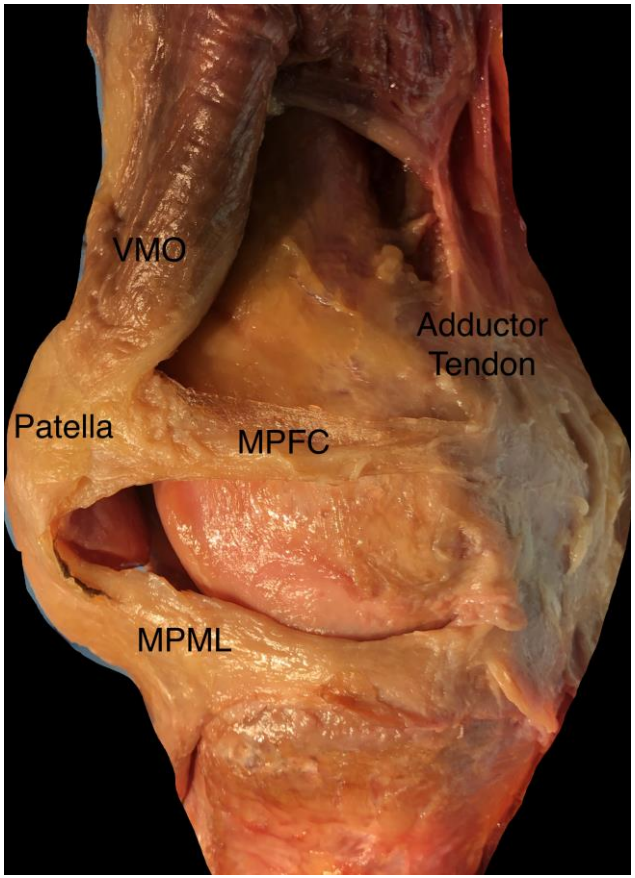
- Quadriceps muscle
  - Lateral
    - Vastus lateralis
    - Vastus intermedius
    - Rectus
  - Medial
    - VMO



www.aafp.org/afp/2007/0115/afp20070115p194

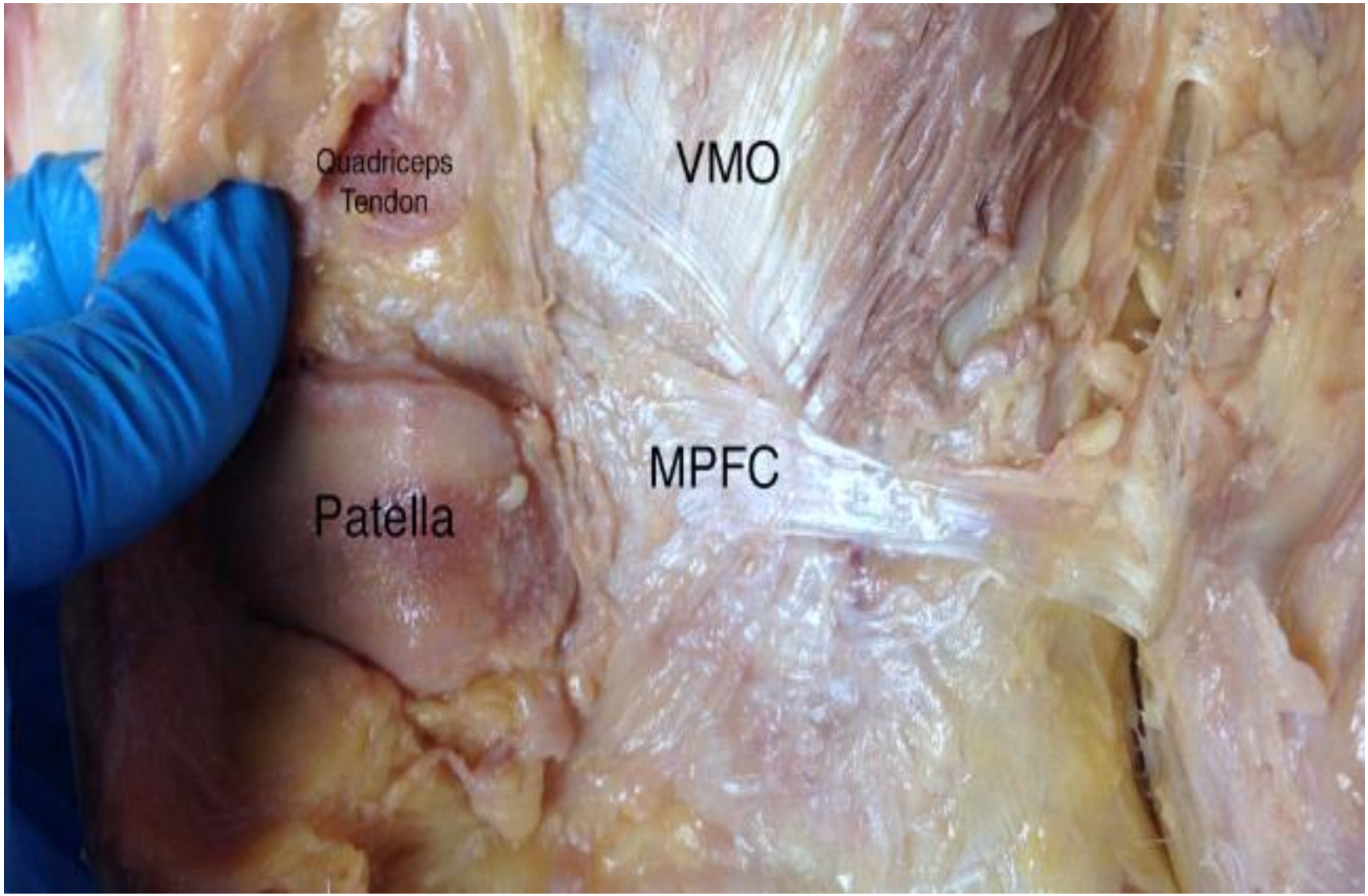
Soft Tissue Restraints

- MPFL: restraint against lateral translation of the patella from 0° to 30° of knee flexion
- Recent change in terminology
- Characteristics
  - low tension throughout flexion-extension (2-10N of force)
  - isometric between 0° and 90°, then becomes slack beyond 90°
  - can withstand 200N before tearing
    - Vs ACL (1725N)



Tanaka et al, Op Tech Sports 2019

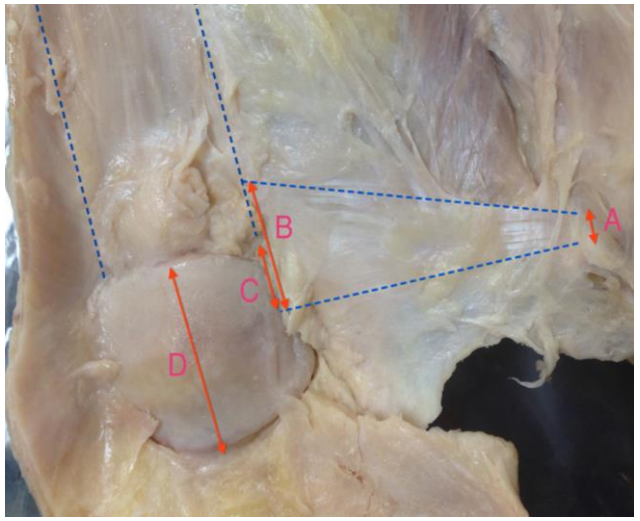
Articular View

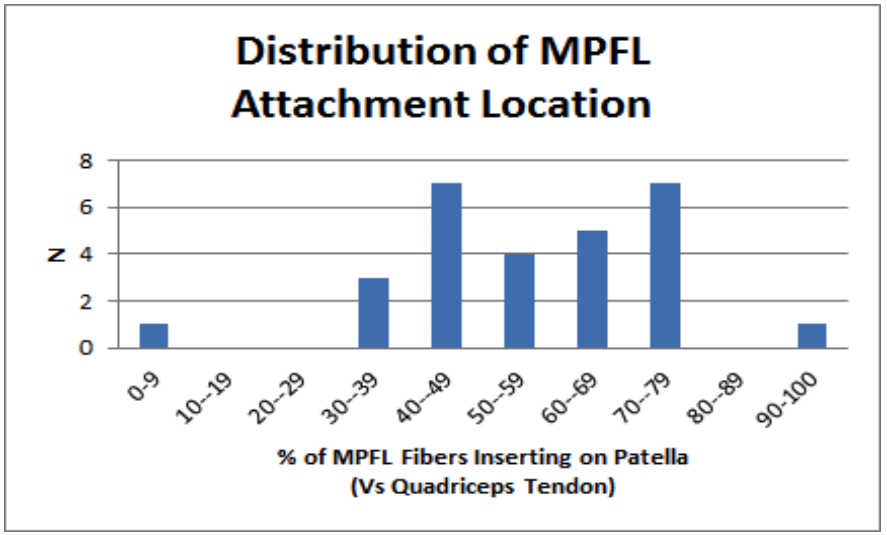


Tanaka MJ, Sports Med Arthrosc. 2017

Anterior Attachment

- Attaches to patella and vastus intermedius (Mochizuki 2014, Tanaka 2016)
- Variable attachment (Tanaka 2016)
  - % of MPFL fibers that attach to patella [C/B]: 57.3 +/- 19.5% (Range 0-100%)

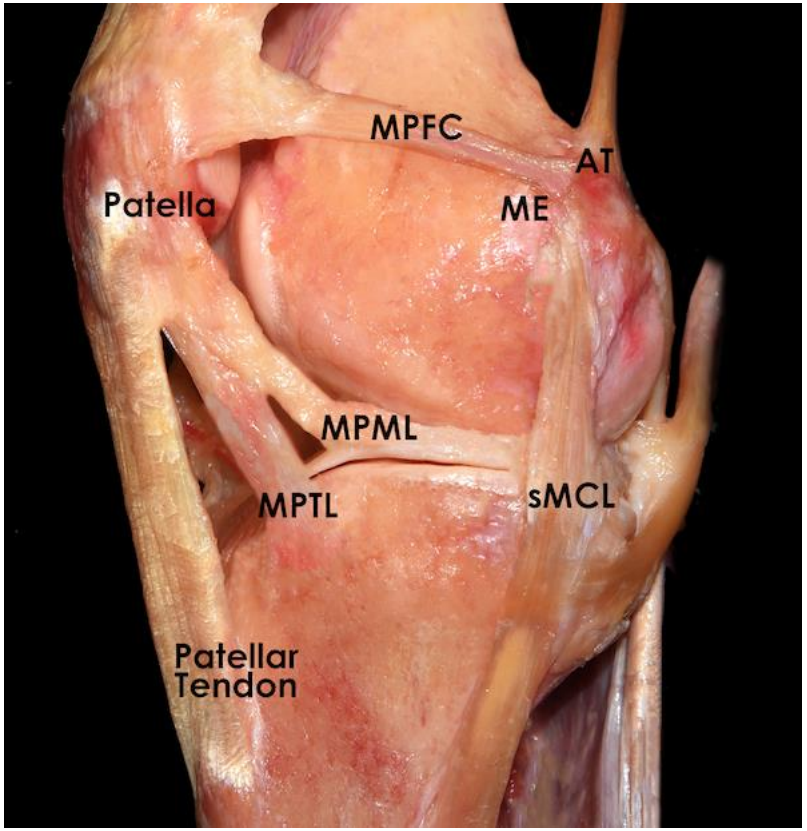




Tanaka MJ, Arthroscopy 2016

Proximal and Distal Restraints

- Proximal (MPFC)
  - MPFL
  - MQTFL
- Distal
  - MPML
  - MPTL

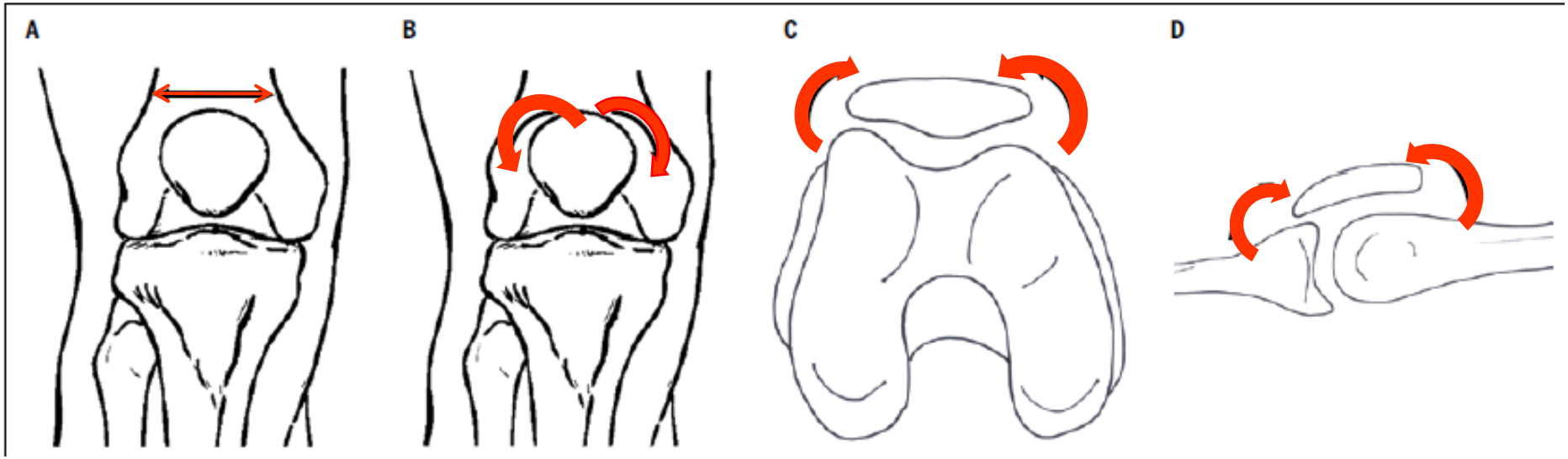


Tanaka et al, KSSTA 2019

Presentation

- Acute and fixed dislocation (uncommon)
  - May present with the knee held in a flexed position
- Femoral condyle prominent medially
  - Patient may mistakenly report a medial dislocation
- Patella often spontaneously reduces with gradual extension of the knee and gentle medially-directed pressure on the patella

Evaluation of Patellofemoral Instability



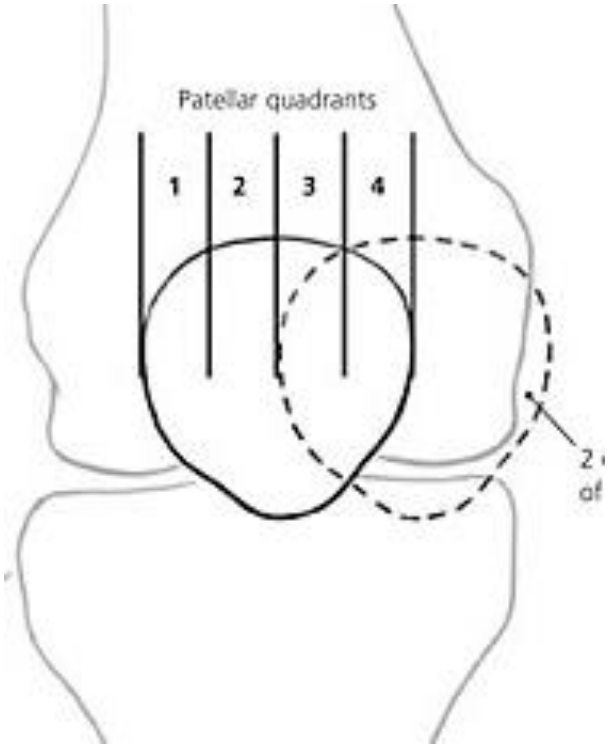
Wilson et al. JOSPT 2007

Clinical Examination

- Ambulation/Gait
- Effusion
- Bruising
- Range of motion
- Ligamentous examination

www.raems.com

Glide test



www.aafp.org/afp/2007/0115/afp20070115p194

Apprehension test

- Performed at 20-30 degrees of flexion

The Adult Knee, Chapters 59-60, Lippincott Williams & Wilkins, 2003

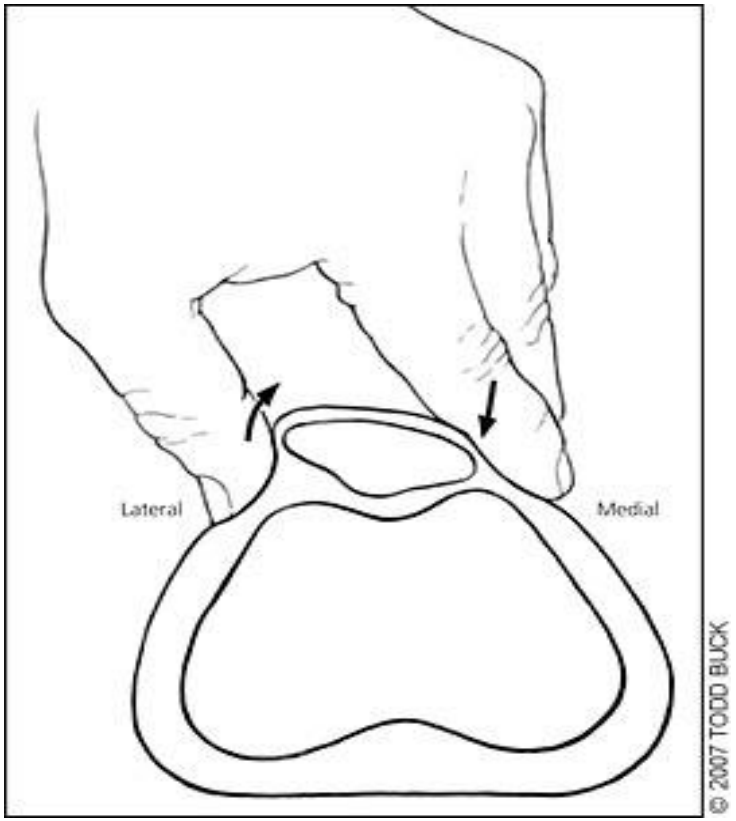
Medial Patellar Instability

- Less common than lateral instability
- High suspicion in any individual who has had previous lateral release
- Imaging may not show findings
- Primarily a clinical diagnosis!
- Increased medial translation with medial apprehension

Tanaka MJ, Op Tech Sports Med 2015

Patellar Tilt test

- Tests for lateral retinacular tightness
  - Should get to horizontal



www.aafp.org/afp/2007/0115/afp20070115p194

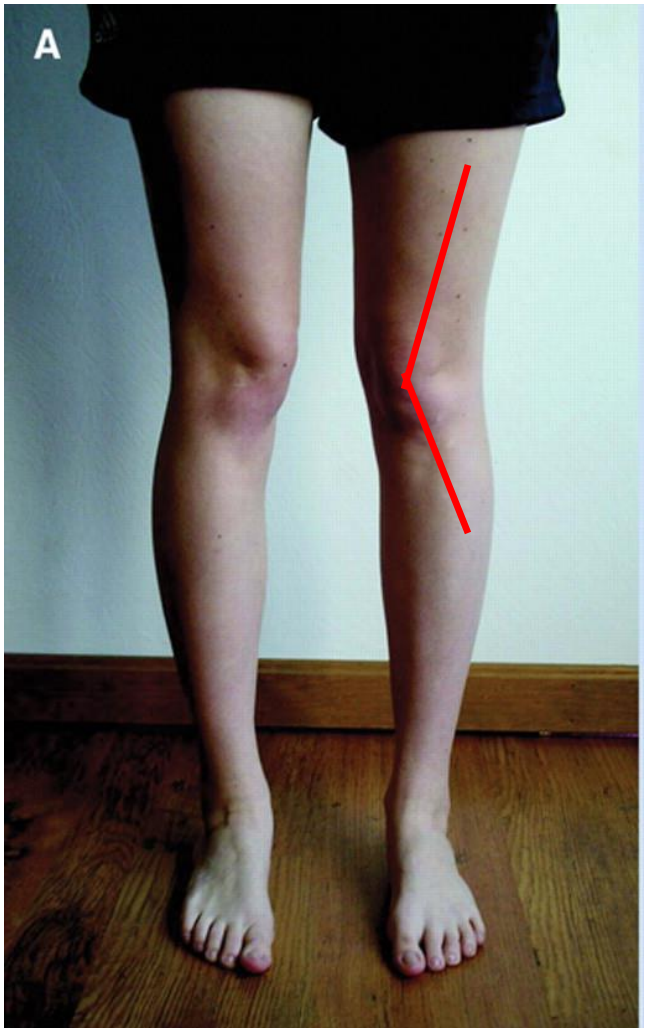
Pain with Patellar Loading

- Loading of patella during active quad contraction causes pain
- =Patellofemoral pain

Sportsinjuryclinic.net

Alignment

- “Miserable malalignment”:
- Femoral anteversion
- Genu valgum
- External tibial torsion
- (Pes planus)



Tanaka et al, OKU Sports Medicine 2015

Q Angle

Image courtesy of A. Cosgarea, MD

- Angle: ASIS-patella, patella-tubercle
  - 14º (M), 17º(F) (Aglietti 1983)
  - Abnormal Q >20º (Wilk 1998, Woodland 1992)
  - Noted in 52% of recurrent instability (Larsen 1982)

J sign

Characterization of patellar maltracking using dynamic kinematic CT imaging in patients with patellar instability

Miho J. Tanaka[1] · John J. Elias[2] · Ariel A. Williams[1] · Shadpour Demehri[3] · Andrew J. Cosgarea[1]

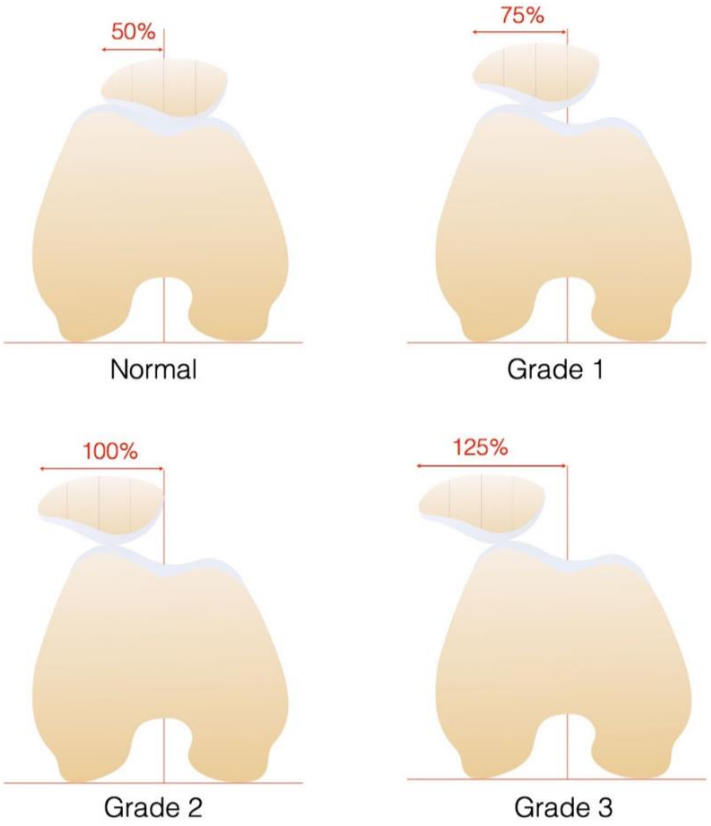


Fig. 3 Using the patellar glide test as a reference, bisect offset was quantified in terms of patellar quadrants of lateralization relative to the deepest portion of the trochlea, with 50 % representing a patella that is centred within the groove

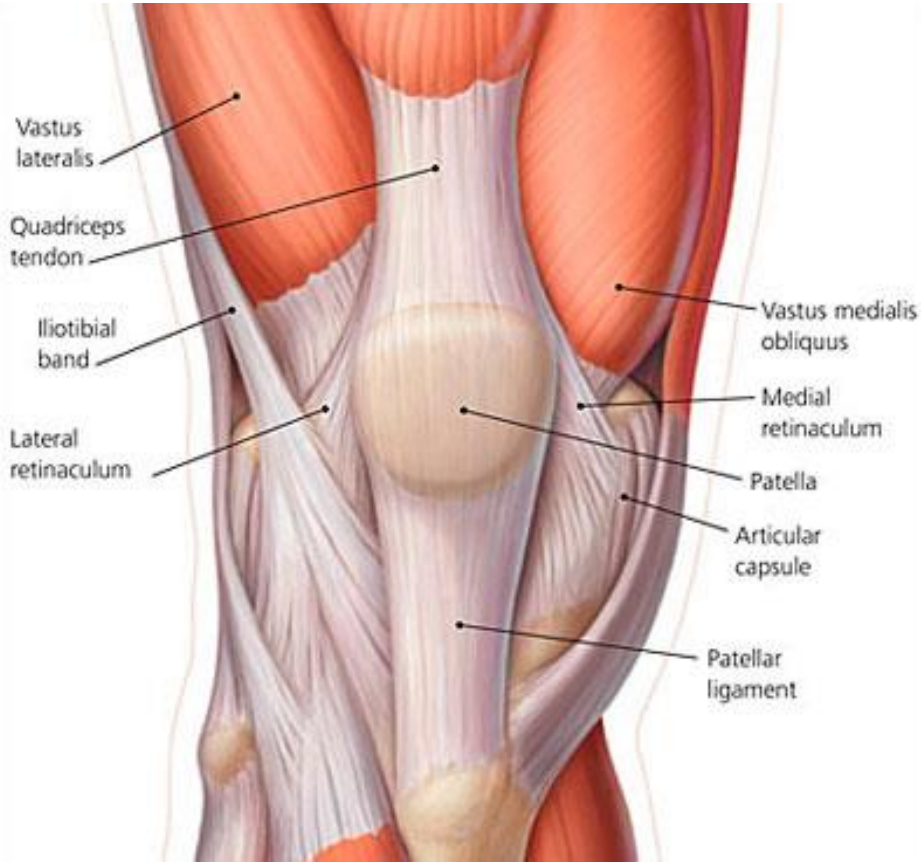
Table 5 Sensitivities of the J sign, versus no J sign, in predicting patellar instability in 58 knees

J-sign grade	Total knees (no.)	Symptomatic knees (no.)	Sensitivity (%)	*p* value[a]
1	24	12	50	0.02
2	19	15	79	
3	15	14	93	
No J sign	16	9	56	

[a] *p* value for difference between J2 and J3 versus J1 and no J sign

VMO Atrophy

- Increases lateral pull of quadriceps mechanism on the patella (Fox 1975)



www.aafp.org/afp/2007/0115/afp20070115p194

Criteria for generalized laxity

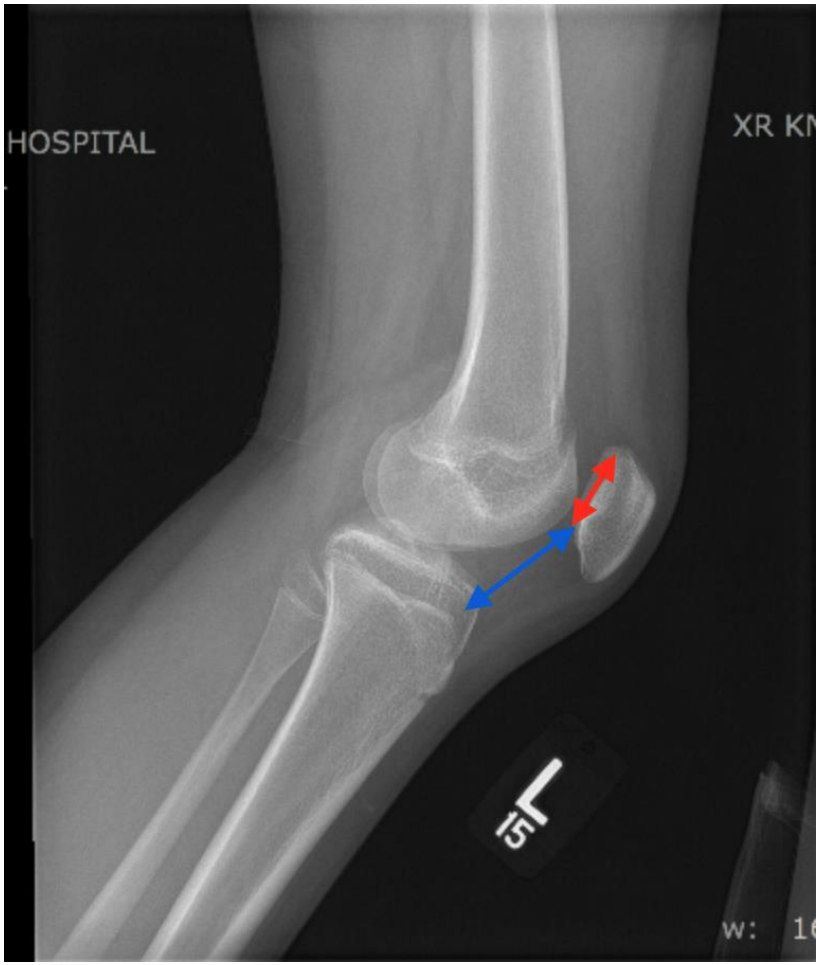
1. Passive thumb abduction to forearm
2. Passive little finger hyperextension to 90
3. Elbow hyperextension >10°
4. Knee hyperextension >10°
5. Trunk flexion

Elias DA, White LM. Clin Radiol 2004;59:543-557

Lateral XR

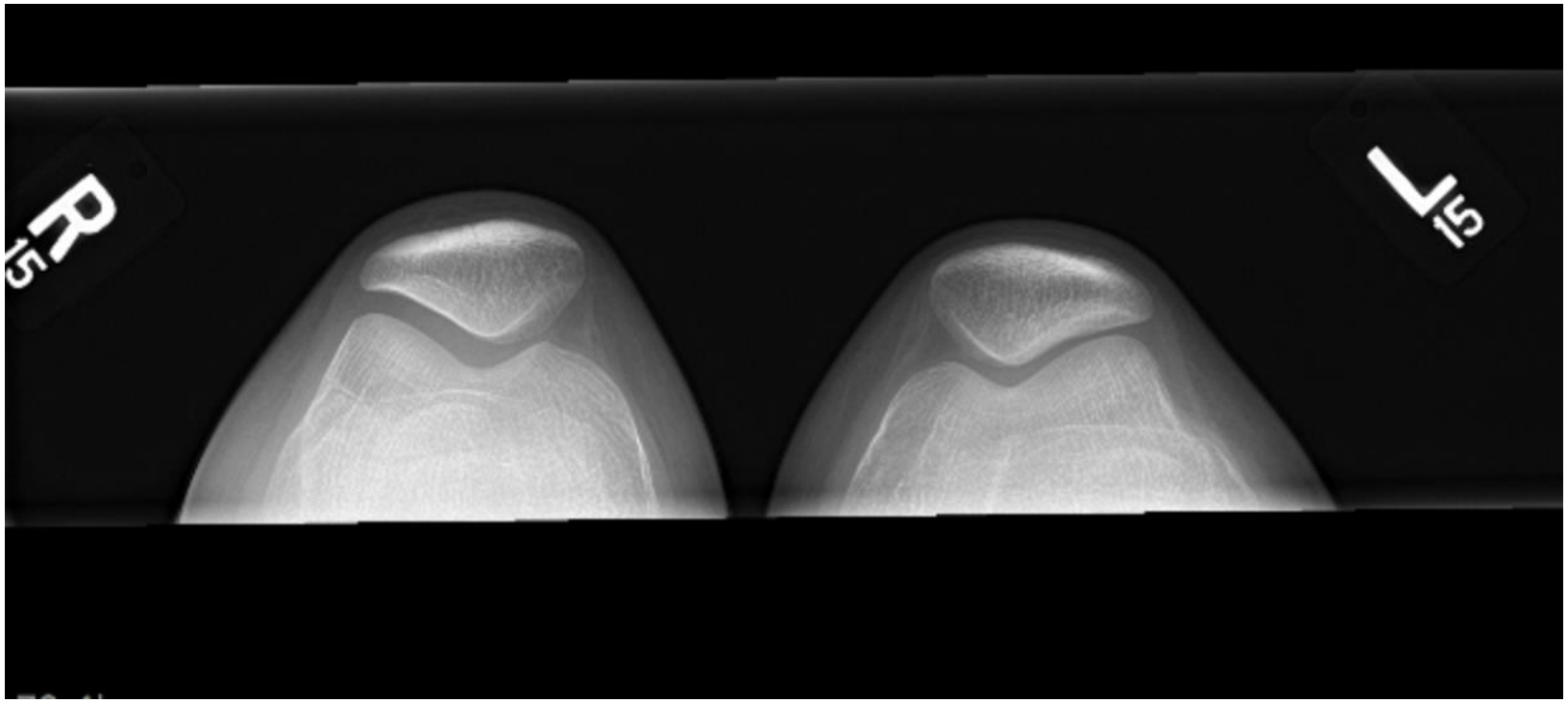
- Patella alta
- Patella baja
- Trochlear dysplasia

Caton Deschamp Index



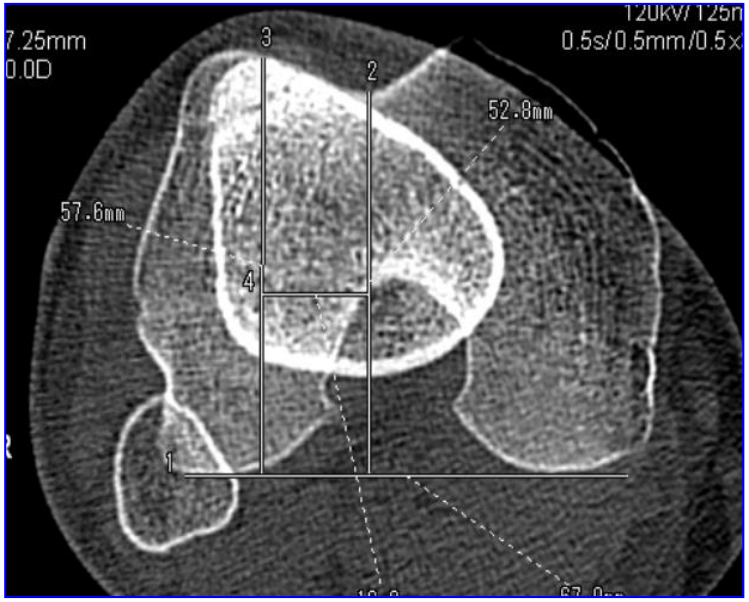
- [length of patellar articular surface]/[distance from distal articular surface to anterior tibial plateau]
- Patella alta > 1.2

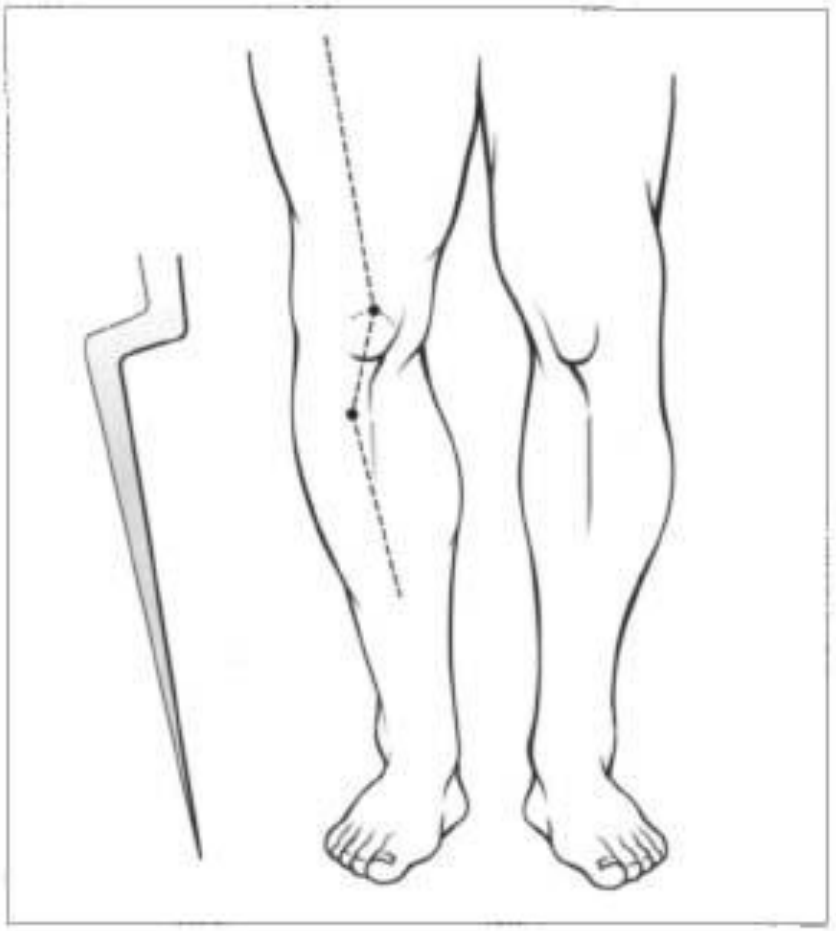
Axial Imaging



- Patellar position
- Trochlear anatomy
- TTTG distance

TTTG Distance



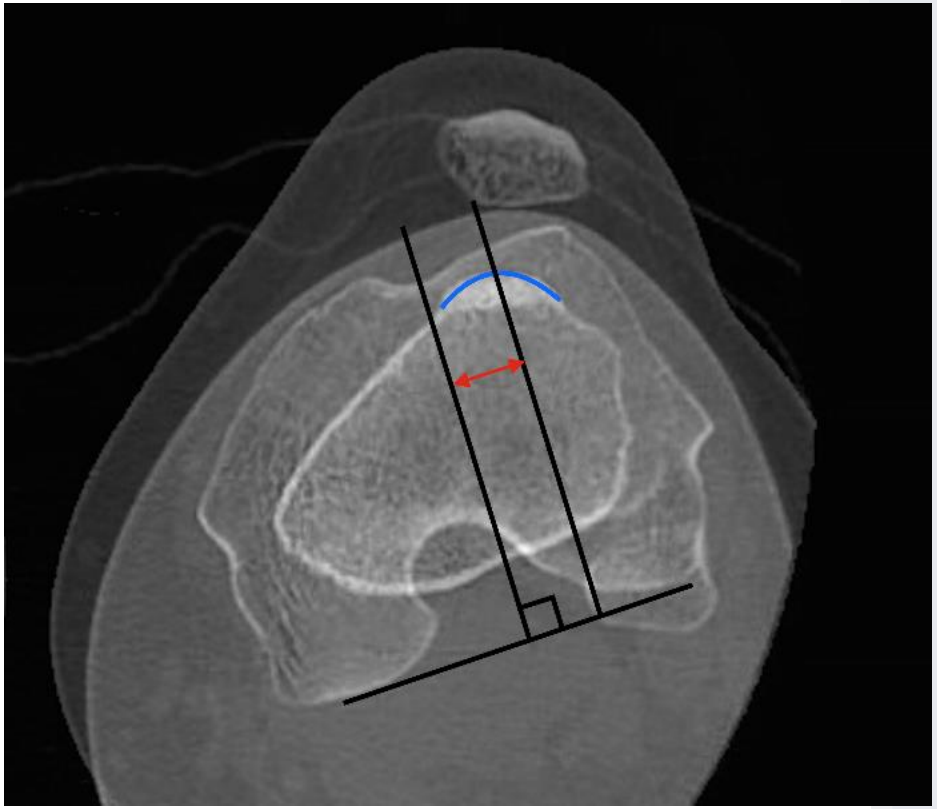


www.aceproindia.com

- Denotes pull of extensor mechanism lateral to groove

TTTG distance

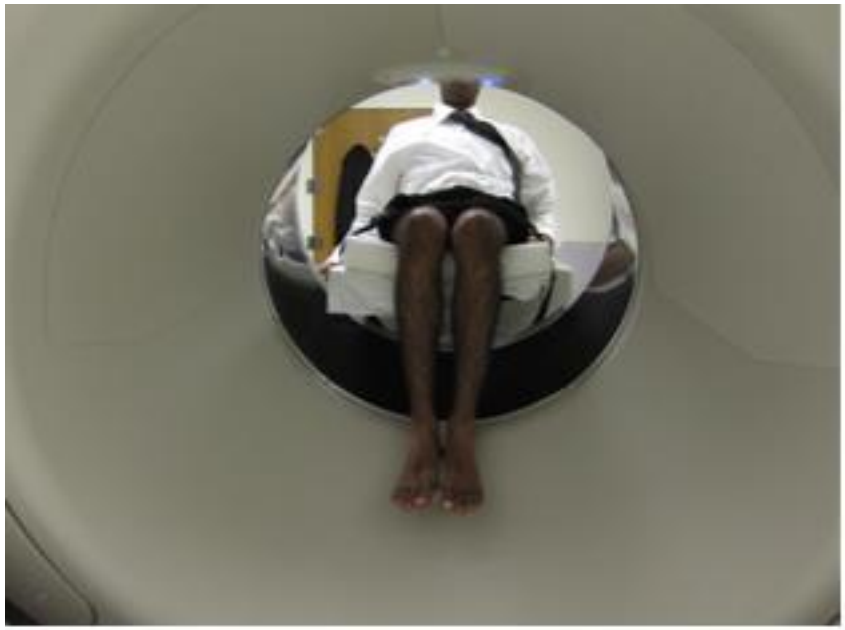
- Measured on CT in extension
- >20mm ”abnormal”
- MRI underestimates by 3.8mm (Camp 2013)
- Changes with knee flexion angle (Tanaka 2015):
  - 4 degrees knee flexion → decreased TTTG by 1mm
- Influenced by patient size (Camp 2015)



Tanaka MJ AJO 2016

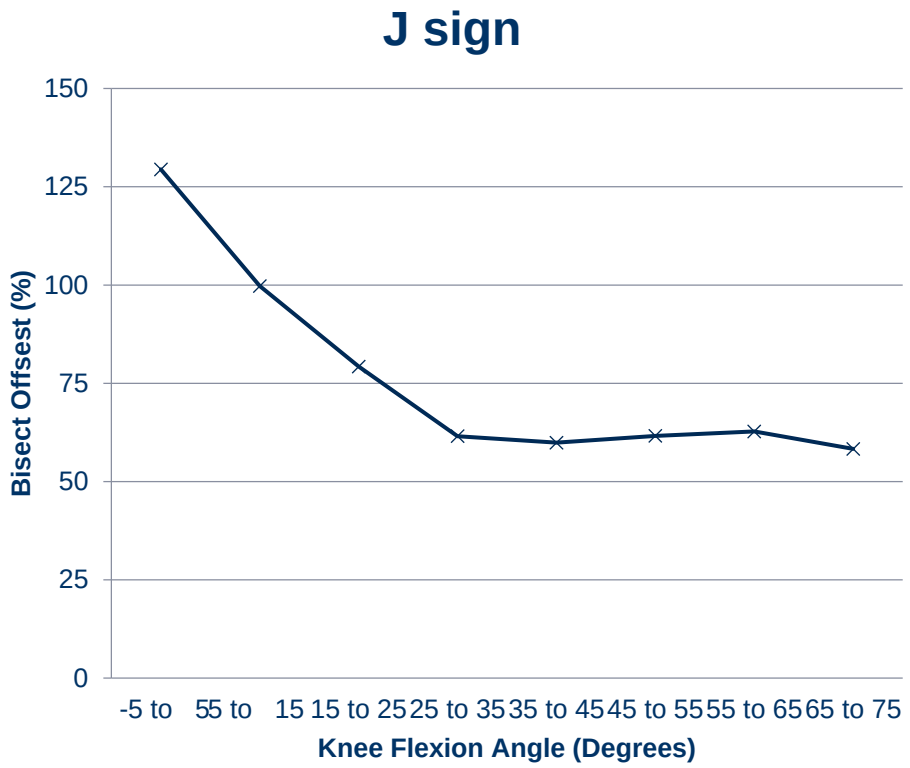
4DCT Imaging

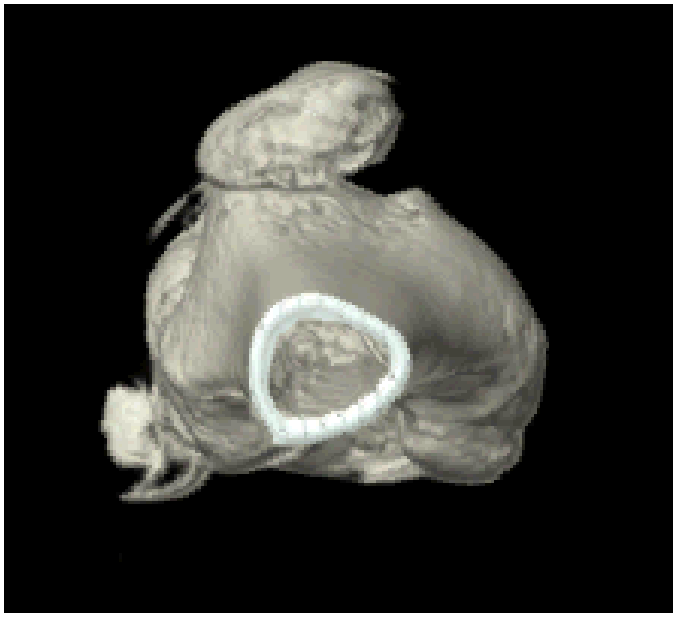
- Patients positioned with knees on cushion, secured with strap
- Active bilateral knee extension over 10s
- Imaging acquired each 0.5s



Tanaka et al, Arthroscopy 2015

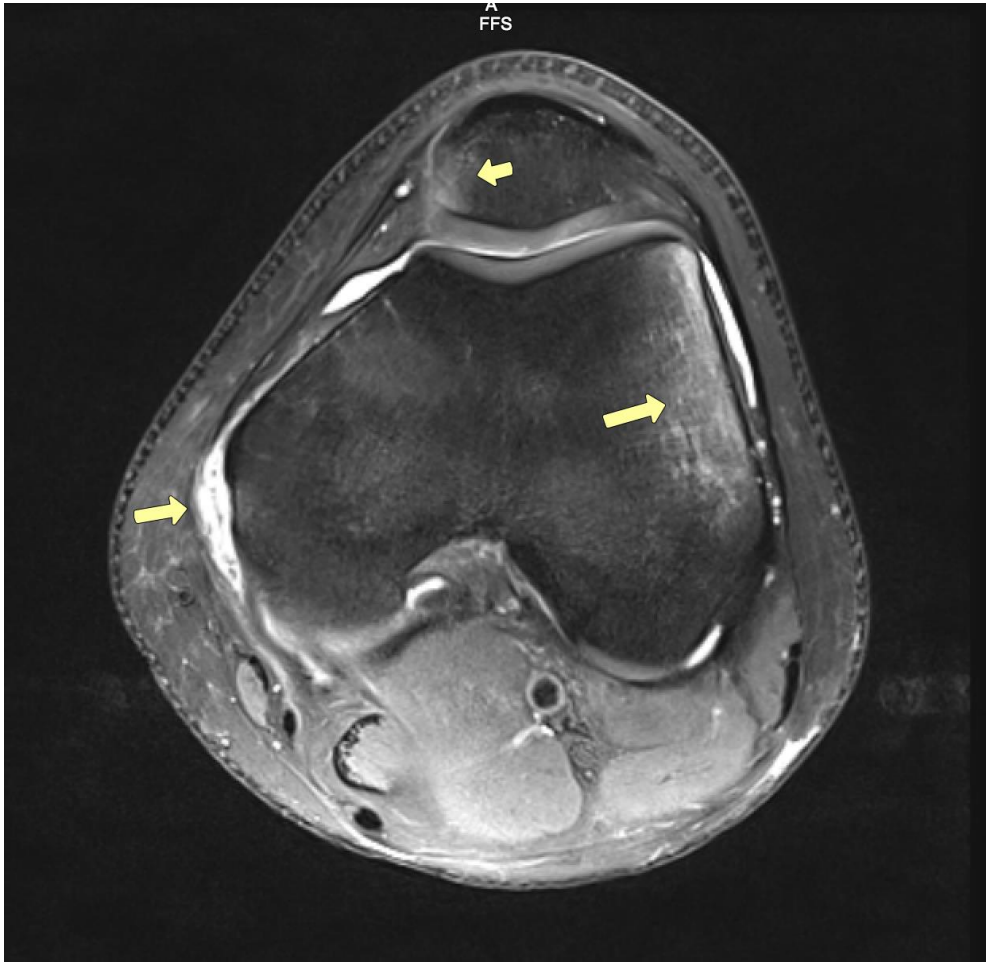
J Sign


J sign
150
125
100
75
50
25
0
Bisect Offsest (%)
-5 to 55
55 to 15
15 to 25
25 to 35
35 to 45
45 to 55
55 to 65
65 to 75
Knee Flexion Angle (Degrees)



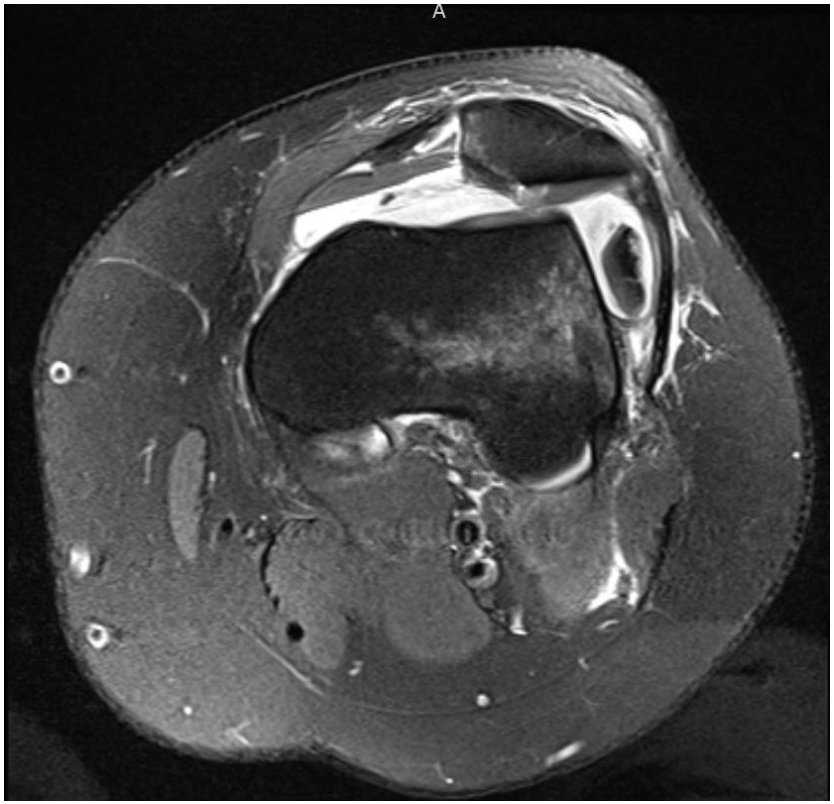
MRI

- MPFL tear
- Chondral fracture LFC
- Chondral fracture of patella
  - (Sallay 1996)



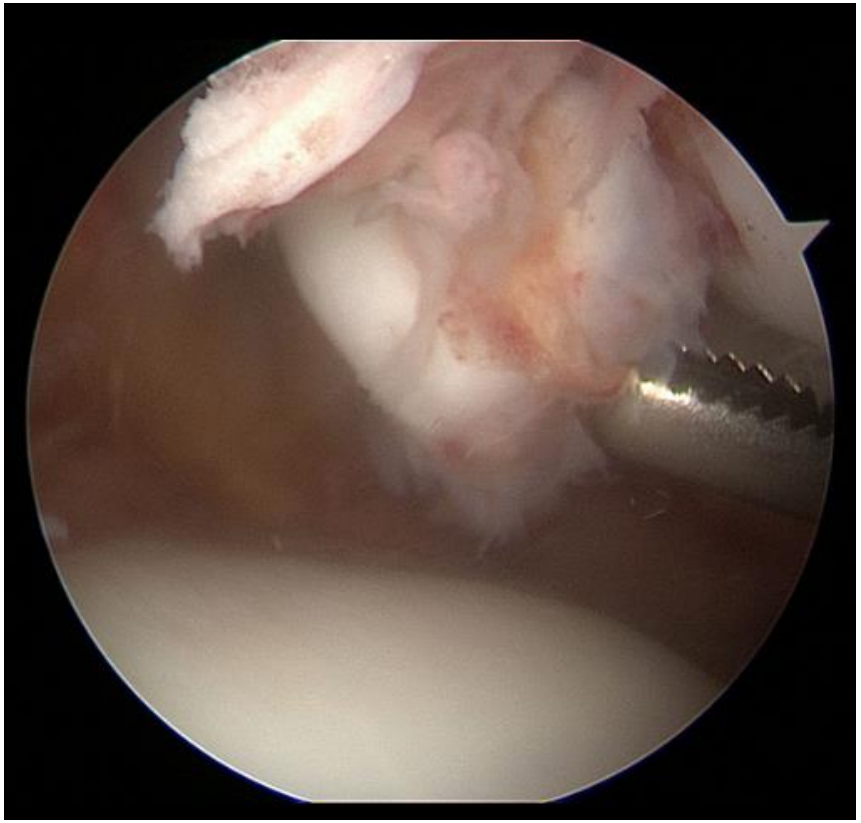
MRI

- Osteochondral injury
- Loose body



Chondral Injury

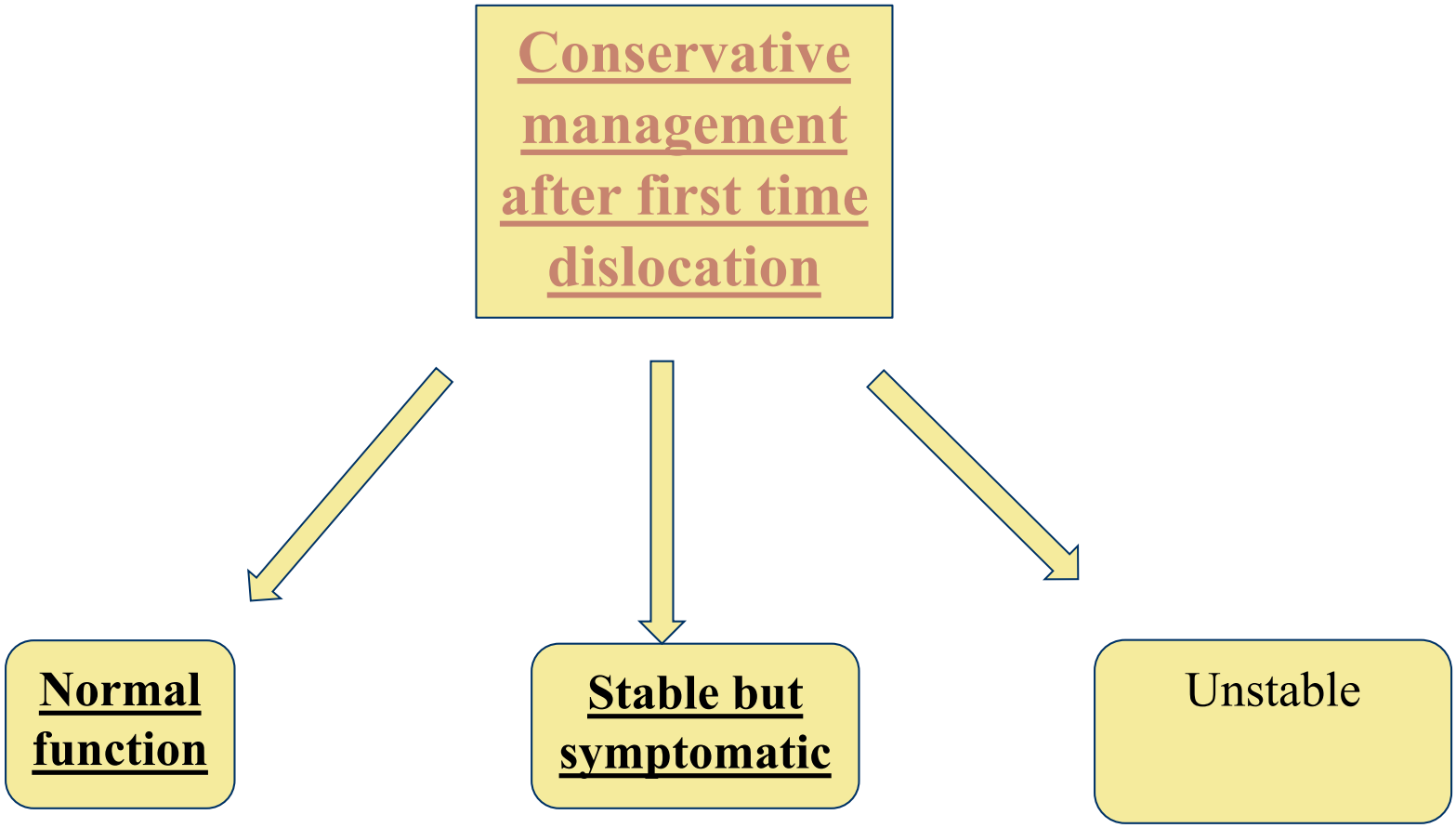
- Early operative intervention
- Repair
- Patellar stabilization procedure



Non-operative treatment

- Lateral buttress brace
- Ice / Anti-inflammatories
- Activity modification
- PT and VMO strengthening

Recurrent Patellar Instability



Failure of non-operative treatment

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- 30-45% recur→ potential indication for surgery
- Risk factors:
  - Female
  - Patella alta
  - Age<18
  - Trochlear dysplasia
  - Increased TTTG (Christensen 2017)

Recurrent Patellar Instability

- Risk factors for recurrence (Jaquith 2017)
  - Skeletal immaturity
  - Bilateral
  - Trochlear dysplasia
  - Patella Alta (CDI > 1.4)

  - 2 risk factors: 55%
  - 3 risk factors: 75%
  - 4 risk factors: 88%

Defining Recurrent Instability

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- Adequate rehabilitation
- Instability that limits function
- Rule out other sources of mechanical symptoms
- Confirm on physical examination
  - Glide test
    - # quadrants translation
    - Compare to other side
  - Apprehension test

Operative Treatment

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- To treat recurrent patellar dislocations
- Surgery is to treat *instability*
  - ➔Surgery does not treat pain!!
- The optimal procedure for stabilization of the patella is tailored to the patient's specific anatomy and type of dislocation.

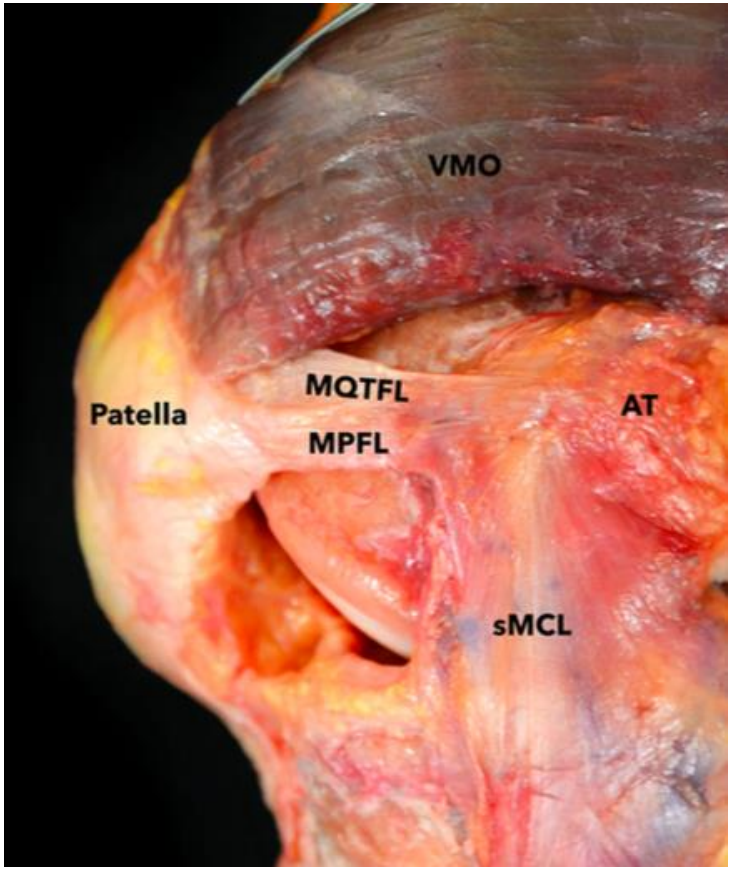
Surgical Treatment: Address Anatomical Deficiencies

Must identify and address the individualized anatomy:

- Soft tissue deficiency
- Bony malalignment
  - Tuberosity lateralization
  - Patellar height
- Trochlear dysplasia
- Maltracking

Soft Tissue Deficiency - MPFL

- Primary static restraint to lateral patellar translation
- Injured after patellar dislocation
- Reconstruction to address cases of recurrent instability
- Anatomic reconstruction is critical in avoiding complications



Tanaka et al KSSTA 2018

Complications after MPFL Reconstruction

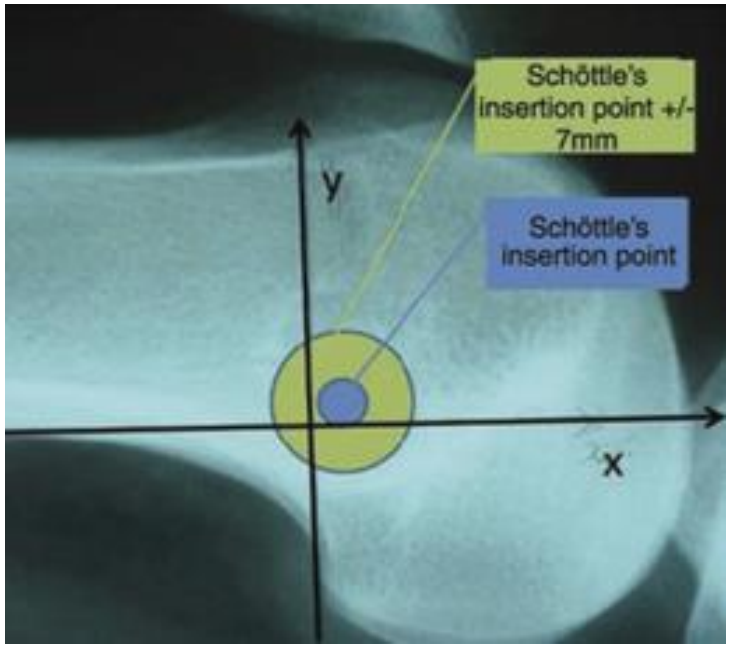
- Complication rate 25.7% (Shah 2012)
  - Patellar fracture
  - ROM loss
  - Increased pain/arthrosis (Tanaka 2012)
- 47% due to improper technique
  - –Graft placement (Parikh 2013)

Femoral Tunnel Malpositioning

- 5mm malpositioning can lead to increased PF contact stresses (Elias & Cosgarea 2006)
- Most commonly too anterior and/or too proximal (Bollier 2011, Servien 2010)

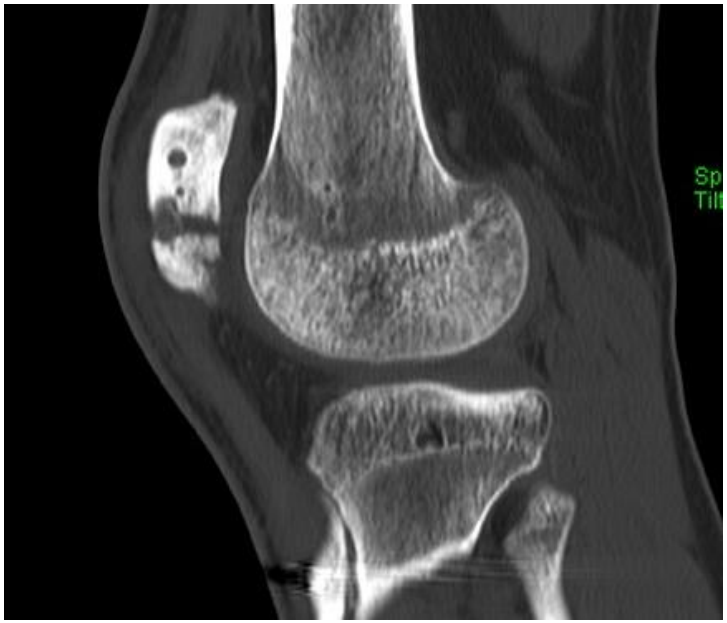
MPFL Anatomy: Femoral Tunnel Position

- Saddle between adductor tubercle and medial epicondyle
  - Can be difficult to find (Servien 2010)
  - Use adductor tendon as guide
- Schottle's Point (2007)
  - 1.3mm anterior to posterior cortical line, 2.5mm distal to proximal posterior femoral condyle
  - Requires perfect lateral (Ziegler 2017)
  - More likely a "cloud" vs "point" (Amis 2012)
- Confirm isometry of graft



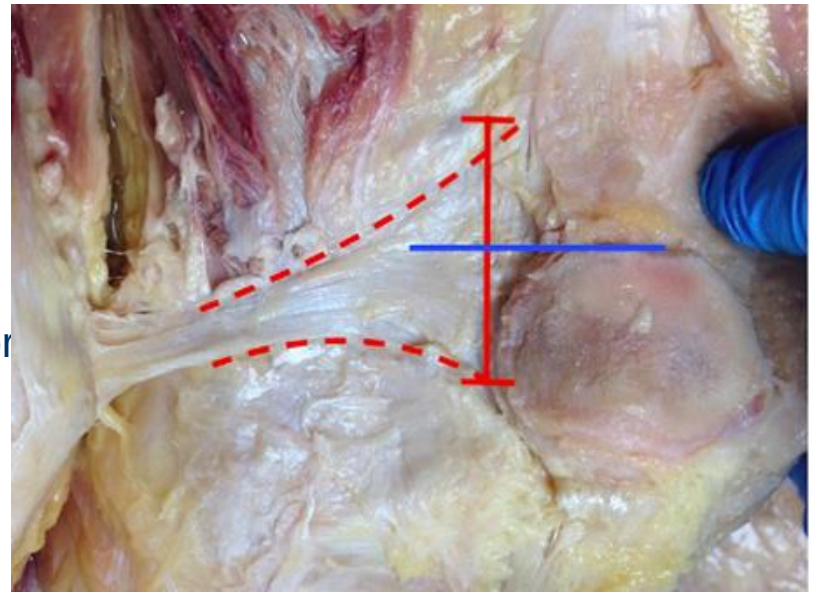
Patellar Fracture After MPFL

- Drilling transversely across patella causes stress riser (Dobbs 2007)
- Double or large tunnels (Parikh 2013)
- Main issue: violation of anterior cortex (Dhawan 2017)



MPFL Anatomy: Patellar Attachment

- 57.3% ± 19.5% fibers attach to patella (Tanaka 2016)
- To confirm placement:
  - Fluoro
    - 19+/-14 % (Tanaka 2018)
    - Confirm NO violation of the anterior cortex
  - Arthrotomy
- MQTFL on quad tendon (Fulkerson 2013)
- Double bundle (Kocher 2018)



Tanaka et al JBJS 2016

Avoid errors of over tensioning

- MPFL only develops tension when the patella is laterally displaced – ie, NO tension at fixation
- Overtightening can lead to arthrosis (Tanaka 2012)
- 3mm shortening can increased medial PF pressures (Elias 2006)

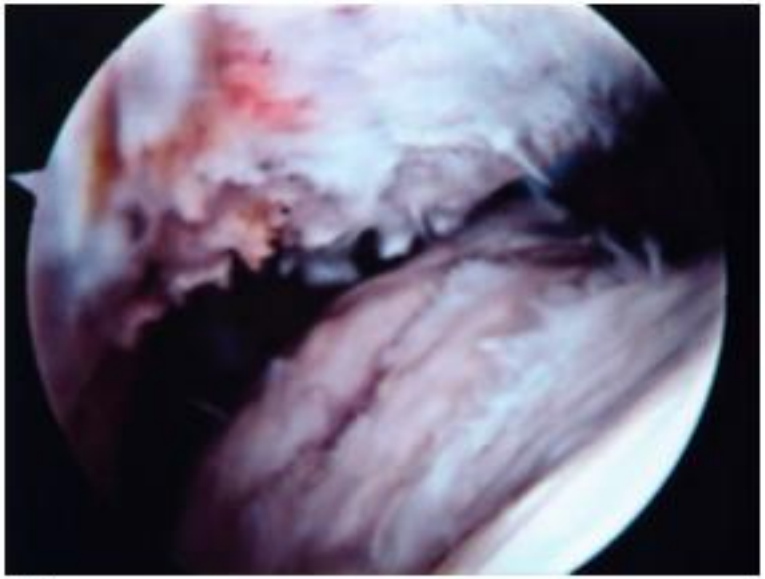


Fig. 4
Arthroscopic view showing advanced erosion over the medial trochlea after overtightening of the medial patellofemoral ligament reconstruction.

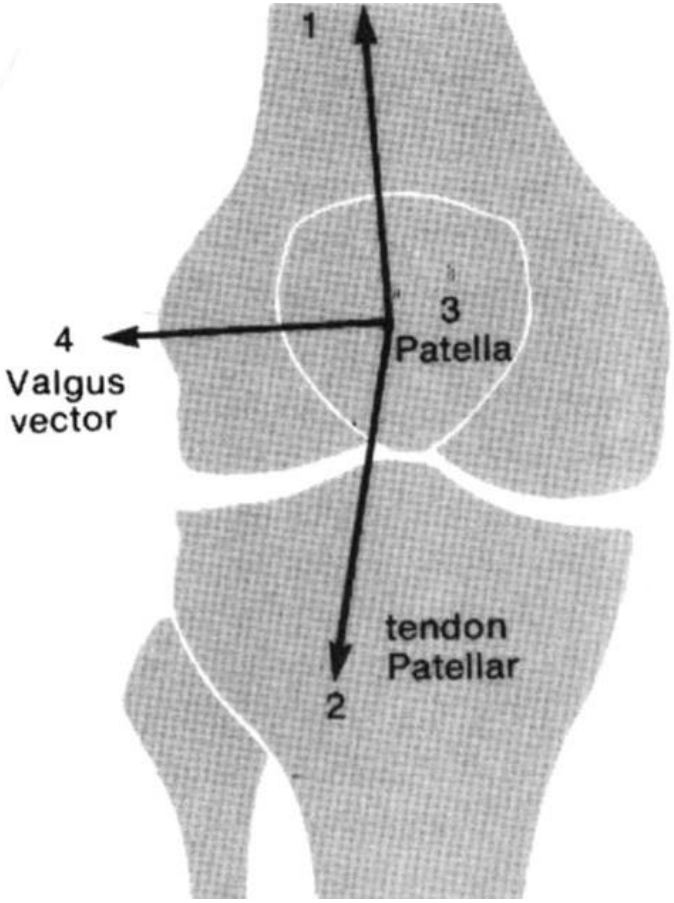
Bony Malalignment

1. Lateralization
2. Patellar Height

Tuberosity Lateralization

- Femoral anteversion
- Genu valgum
- External tibial torsion

- Leads to lateralizing force on extensor mechanism

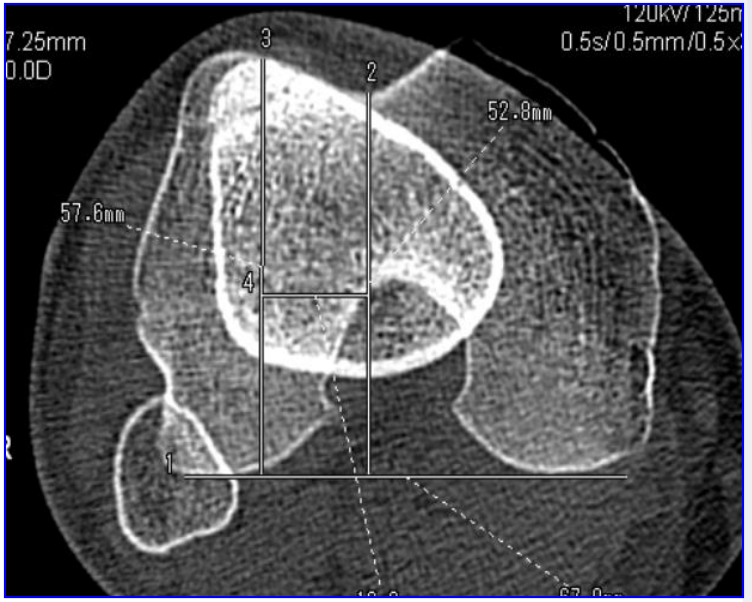


TTTG distance

>20mm ”abnormal”

Changes with knee flexion angle (Tanaka 2015):

Influenced by patient size (Camp 2015)



When/why should we add TTO?

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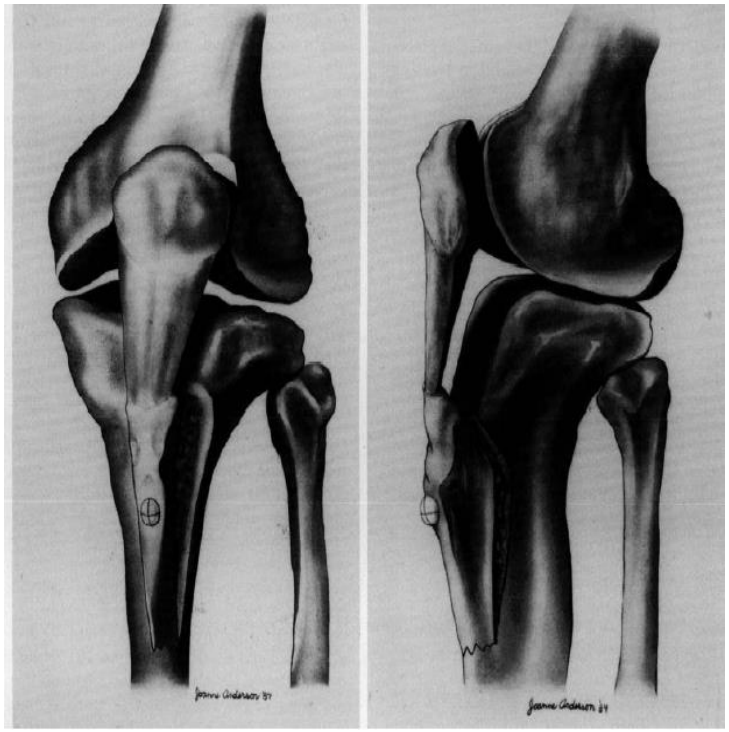
MPFL recon does not restore normal kinematics when TTTG>15mm (Stephen 2015)

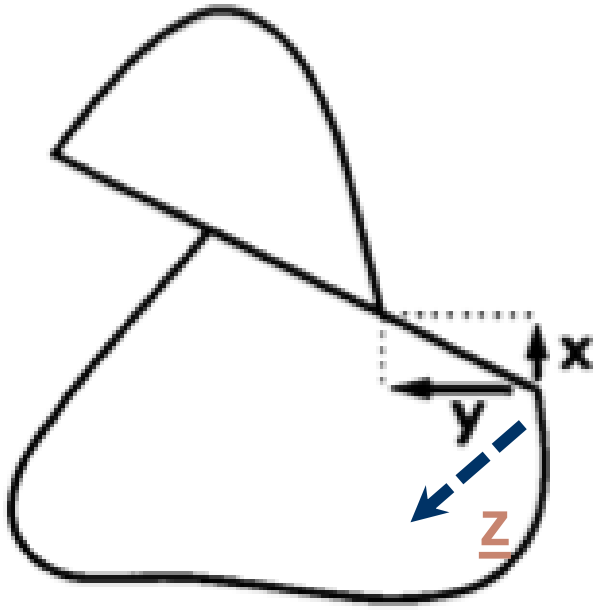
Increased anisometry of MPFL graft with TTTG>20mm (Redler 2018)

No clinical studies



Tibial Tuberosity Osteotomy

- Medialize: if TTTG>20mm
- Anteriorize: if chondral lesions
- Distalize (use caution!) if CD > 1.4
  - Higher rate of delayed union (Johnson 2018)



Complications during TTO

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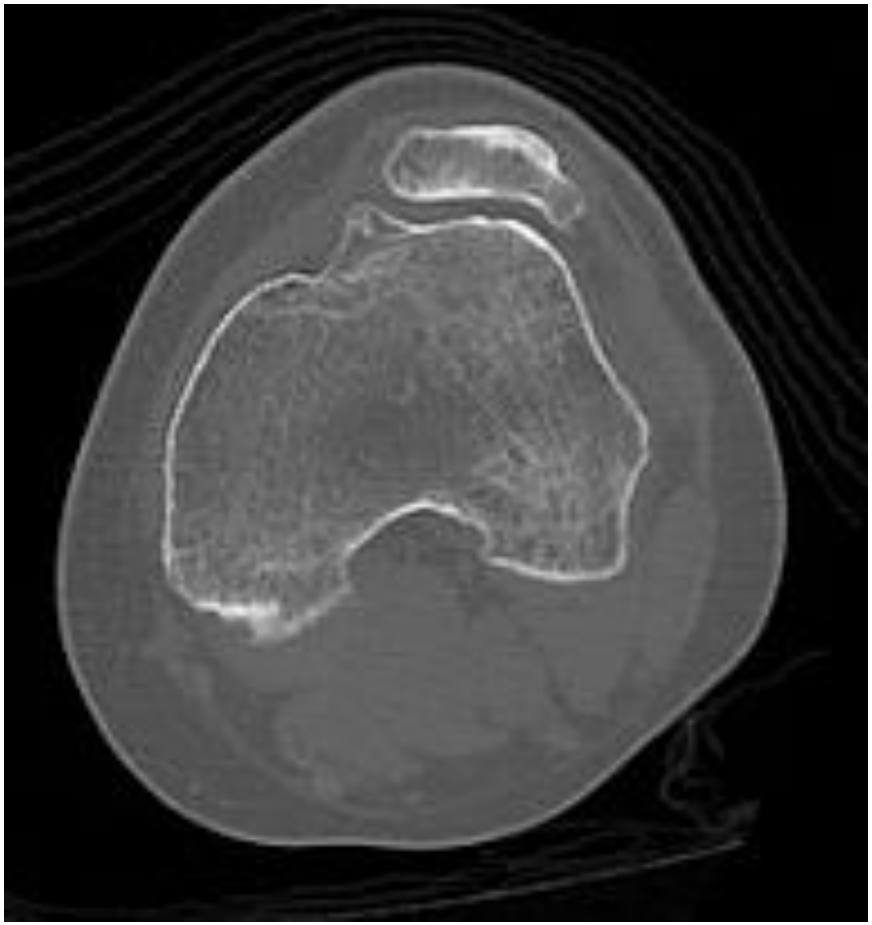
- Tibia fracture
  - Immediate (Stetson 1997, Luhmann 2011, Bellemans 1998)
  - Delayed (Godde 2001)
- Shingle fracture
- Vascular Injury (Kline 2006)
- Compartment syndrome (Wiggins 1975)
- DVT 3.8% (Tanaka, Munch, Shubin Stein 2013)

Trochlear Dysplasia

- Present in 96% with patellar instability
- Leads to decreased bony constraint
- NOT necessarily an indication for trochleoplasty
  - Albee (raising lateral wall)
  - DeJour (deepening)

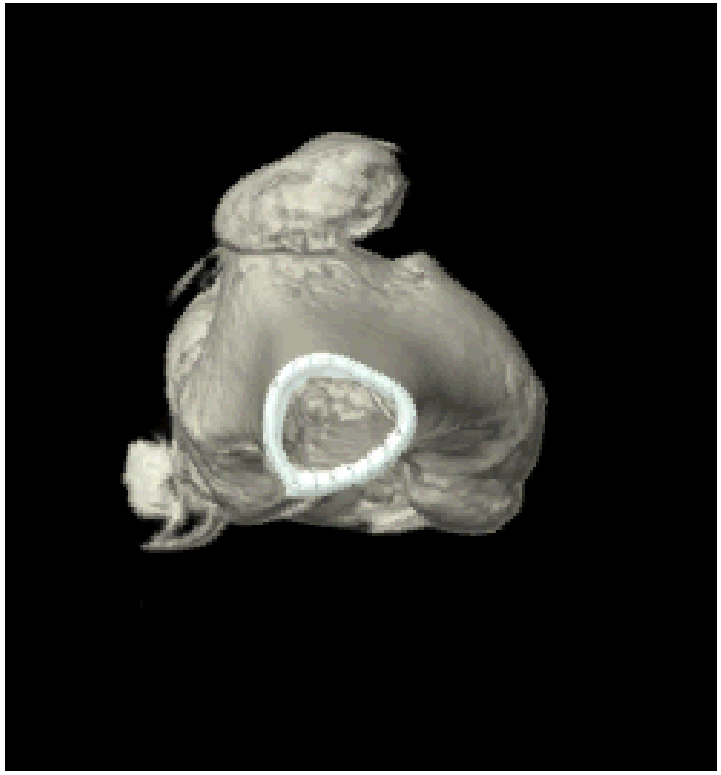


Trochleoplasty??

- Indications still unclear
- Not commonly performed in US
  - High complication rate
  - Improves stability but increases pain
- Absolute contraindications
  - Open physes
  - Arthritis
- Reserved only for cases where stability cannot be achieved using other measures

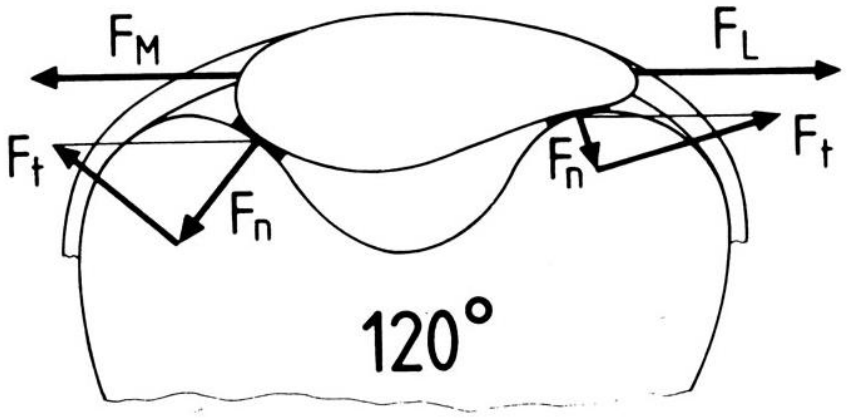
Maltracking

- Abnormal patellar motion during knee ROM
  - J sign
- Classification based on 4DCT
  - >3 quadrants lateralization = 93% symptomatic (Tanaka 2016)
- Clinical assessment still difficult (Best 2018)



Can Lateral Release Correct This?

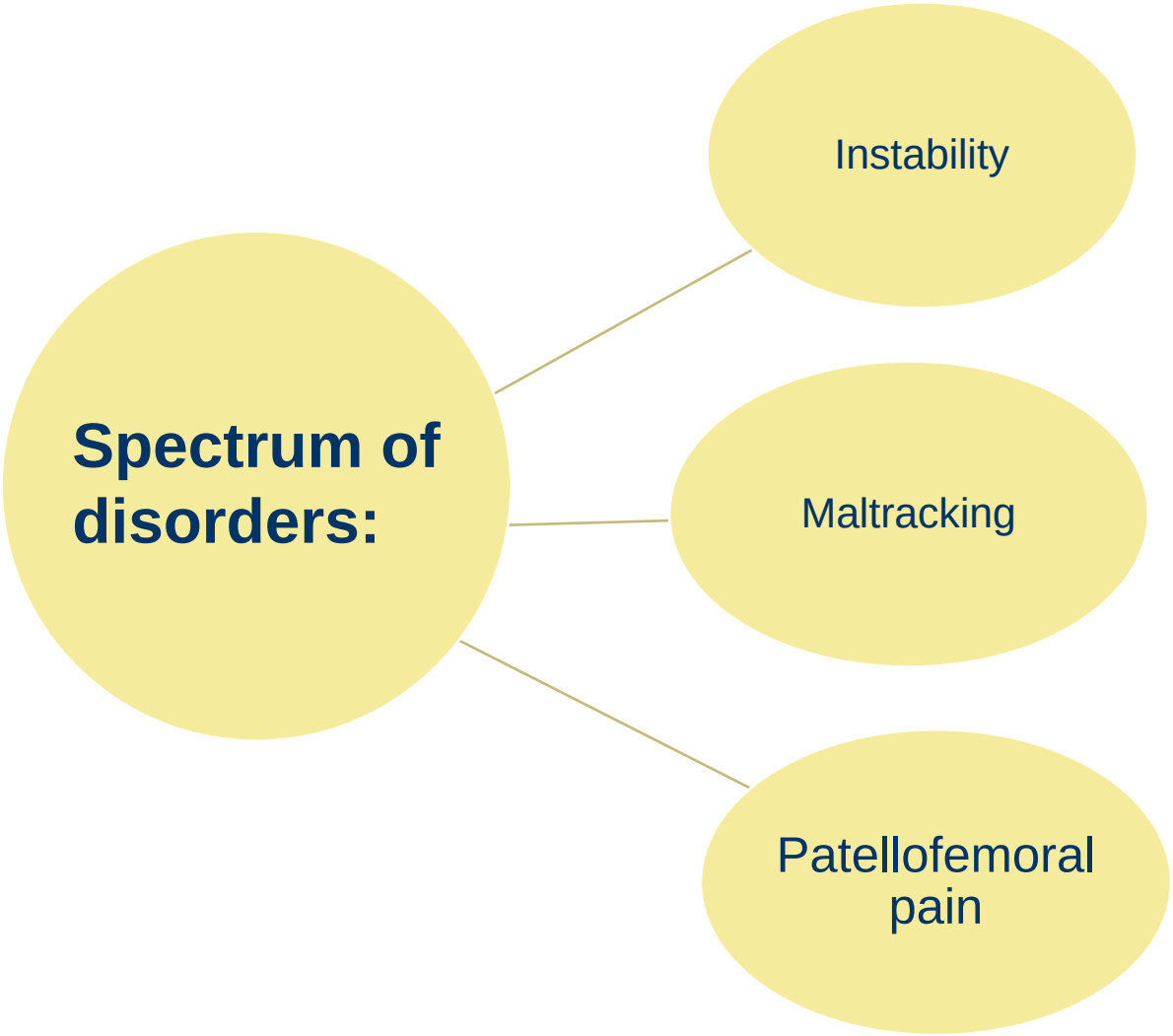
- NO!!
- Can worsen lateral patellar instability
- Can cause medial patellar instability



Beware the Lateral Release

- Indications for isolated LR are limited
- History of prior surgery should raise suspicion
- Always check for medial instability
  - Can be mistaken for lateral instability
  - In the setting of both, correct more symptomatic side and reassess

Patellofemoral disorders



Patellofemoral Pain Syndrome

- Pain without instability
- Overloading of patellofemoral joint

Causes

- Subtle Maltracking
- Acute Trauma
- Chronic Overload

- → Pain

Mechanism

- Quad inhibition
- Alters the loadbearing of the patellofemoral joint
- Irritation of the PF joint

- Scott Dye, MD
- UCSF

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Conscious Neurosensory Mapping of the Internal Structures of the Human Knee Without Intraarticular Anesthesia

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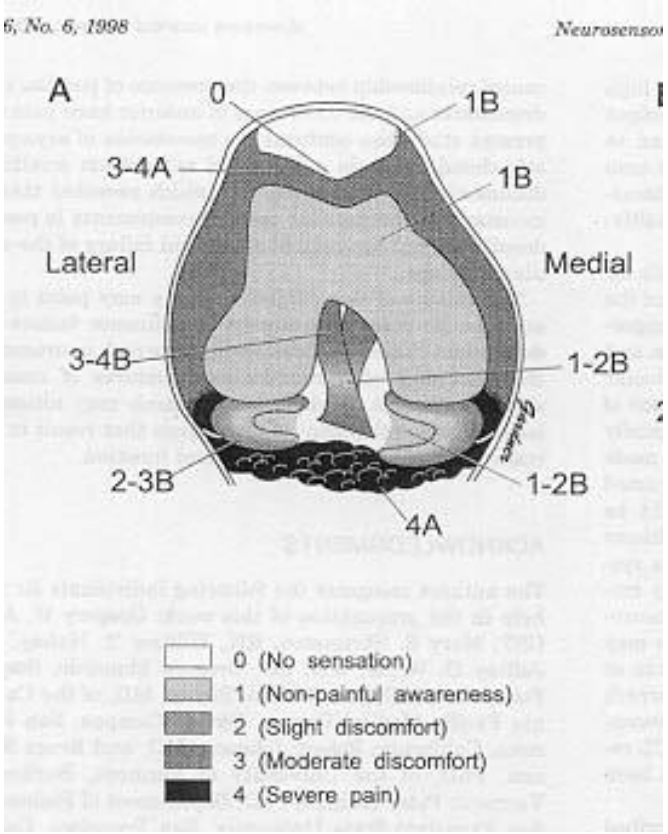
ABSTRACT

The conscious neurosensory characteristics of the internal components of the human knee were documented by instrumented arthroscopic palpation without intraarticular anesthesia. With only local anesthesia injected at the portal sites, the first author (SFD) had both knees inspected arthroscopically. Subjectively, he graded the sensation from no sensation (0) to severe pain (4), with a modifier of either accurate spatial localization (A) or poor spatial localization (B). The nature of the intraarticular sensation was variable, ranging from 0 on the patellar articular cartilage to 4A on the anterior synovium, fat pad, and joint capsule. The sen-

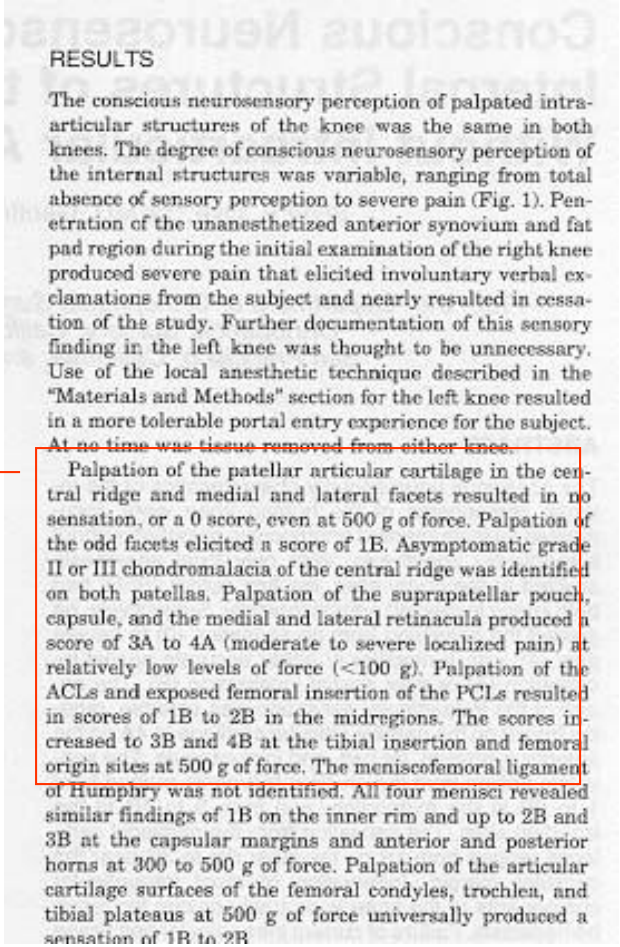
patella, and fibula.[9] The ligaments act as adaptive linkages, with the menisci representing mobile bearings. Current data indirectly indicate that various intraarticular components of the knee are sensate, that is, they generate neurosensory signals that reach the spinal, cerebellar, and higher central nervous system levels. These signals ultimately result in conscious perception. The main research studies supporting this belief have been based on histologic evidence of neural structures within intraarticular components,[4,7,14–17,19,20,23,28,29,34,35] the documentation of sensory evoked potentials,[26] or on proprioceptive characteristics of the human knee.[2,3,6,24,27,30,31] Proprioceptive studies have been primarily designed to elicit conscious detection of small movements of the knee. Such

- 0: no sensation
- 1: non painful
- 2: slight discomfort
- 3: moderate discomfort
- 4: severe pain



Patellofemoral sensory mapping

- Patellar cartilage: 0
- ACL: 1-2
- ACL insertion: 3-4
- Meniscus: 1-2
- Articular cartilage: 1-2



RESULTS

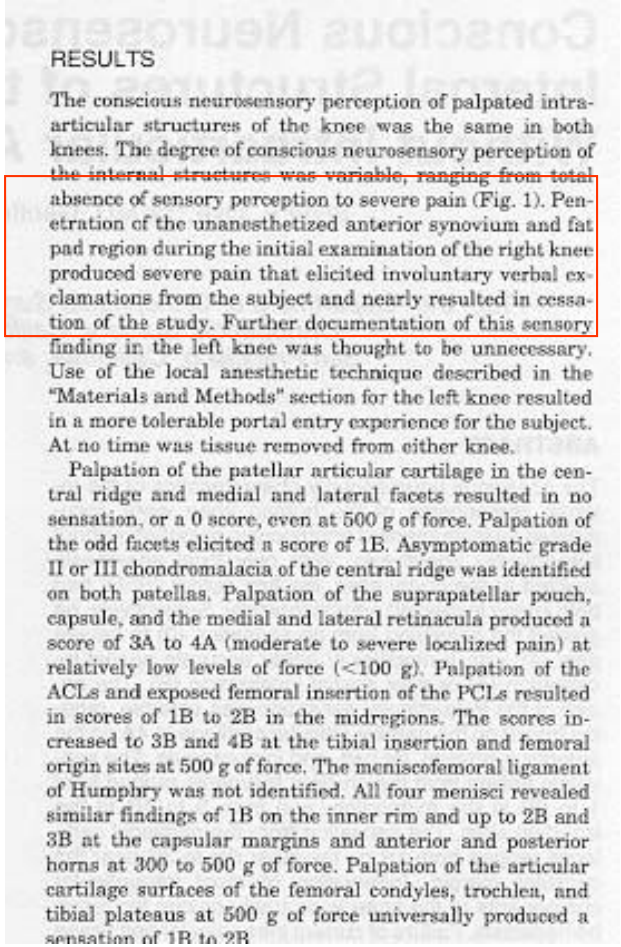
The conscious neurosensory perception of palpated intra-articular structures of the knee was the same in both knees. The degree of conscious neurosensory perception of the internal structures was variable, ranging from total absence of sensory perception to severe pain (Fig. 1). Penetration of the unanesthetized anterior synovium and fat pad region during the initial examination of the right knee produced severe pain that elicited involuntary verbal exclamations from the subject and nearly resulted in cessation of the study. Further documentation of this sensory finding in the left knee was thought to be unnecessary. Use of the local anesthetic technique described in the "Materials and Methods" section for the left knee resulted in a more tolerable portal entry experience for the subject. At no time was tissue removed from either knee.

Palpation of the patellar articular cartilage in the central ridge and medial and lateral facets resulted in no sensation, or a 0 score, even at 500 g of force. Palpation of the odd facets elicited a score of 1B. Asymptomatic grade II or III chondromalacia of the central ridge was identified on both patellas. Palpation of the suprapatellar pouch, capsule, and the medial and lateral retinacula produced a score of 3A to 4A (moderate to severe localized pain) at relatively low levels of force (<100 g). Palpation of the ACLs and exposed femoral insertion of the PCLs resulted in scores of 1B to 2B in the midregions. The scores increased to 3B and 4B at the tibial insertion and femoral origin sites at 500 g of force. The meniscofemoral ligament of Humphry was not identified. All four menisci revealed similar findings of 1B on the inner rim and up to 2B and 3B at the capsular margins and anterior and posterior horns at 300 to 500 g of force. Palpation of the articular cartilage surfaces of the femoral condyles, trochlea, and tibial plateaus at 500 g of force universally produced a sensation of 1B to 2B

- Anterior synovium and fat pad region:

"…Produced severe pain that elicited involuntary verbal exclamations from the subject and nearly resulted in cessation of the study."

%*#$^



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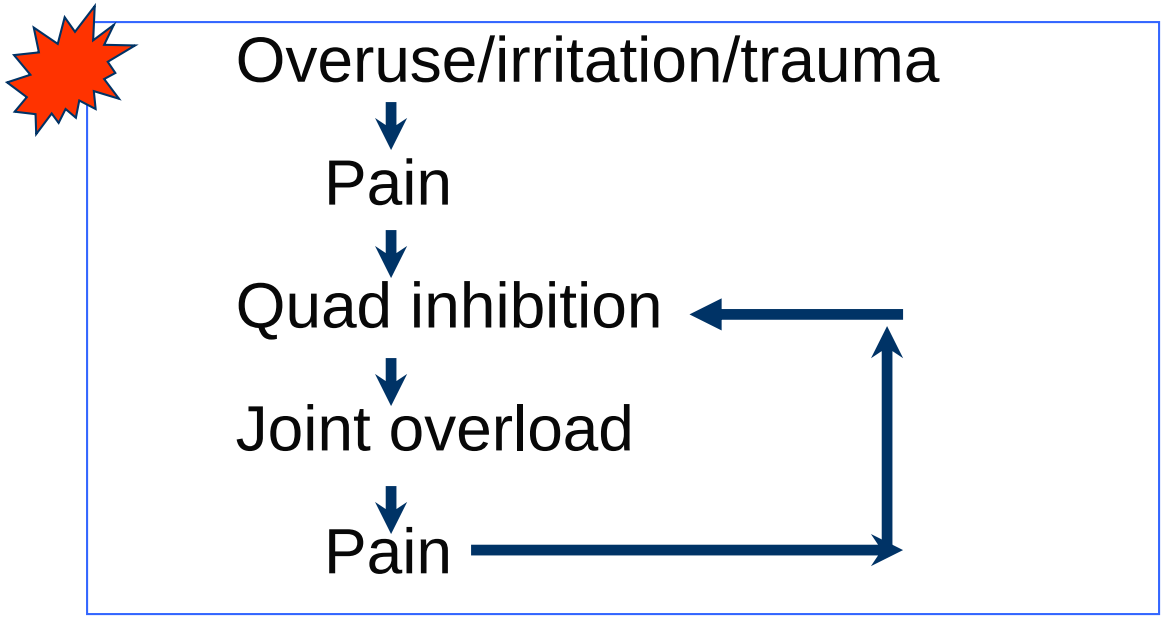
My philosophy on PFPS

- Grinding/chondral injury ≠ pain



My philosophy on PFPS

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- Treatment:
  - Address inflammation
    - NSAIDS/ice
    - Activity modification
  - Quadriceps strengthening without overloading
    - Protects PF joint
    - Add hamstring stretching, etc
  - Address malalignment
    - Patellar taping, arch support, VMO strengthening
  - Patient education & maintenance

Summary

- Patellofemoral disorders are a spectrum between pain and instability
- Multifactorial in nature
- Physical exam critical to detect and confirm instability
- Individualize treatment and address the deficiency

Summary

- 1st time patellar dislocations don't often need surgery
  - Unless: osteochondral loose body
- Recurrent instability needs to be addressed
- History and physical exam are critical!

Summary

- MPFL reconstruction
  - Avoid complications! Know the anatomy!
  - Tunnel placement and graft tension
- Address malalignment (lateralization and height) with TTO when needed
- Trochleoplasty: Only if cannot achieve stability (convex trochlea)
  - Refer
  - Future area of study
- Medial Instability: Don’t miss it!
  - Don’t cause it!
  - Lateral release: very limited indications

Summary

- Treatment goals:
  - Identify and address contributing factors
  - Stability
  - Pain control
  - Patient (and provider) education

Thank You

MASSACHUSETTS GENERAL HOSPITAL